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Blockchain

The “phare” of Innovative Entrepreneurship

UNIVERSITY of the AEGEAN

Information and Communication Systems Engineering

Master of Science in Technologies and Management of Information and Communications Systems

“Digital Innovation and Entrepreneurship”

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Ο «φάρος» της Καινοτόμου Επιχειρηματικότητας

Diploma Thesis

of

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A B S T R A C T

The subject of this diploma thesis was chosen in order to cover both aspects of postgraduate program "Digital Innovation and Entrepreneurship". Entrepreneurship and innovation are two terms tightly bonded together which both are effecting social life and governance. Entrepreneurial start-ups armor the economy by inventing new ideas, digging out new opportunities and canalize resources to them. On the other hand, the already founded companies innovate in order to come up against their competition. While in the public sector, the need for effective policies as to cope with new challenges such as the need for increasing service delivery combined with budgets decrease also benefits innovative thinking.

"Innovation and entrepreneurship are recognized as key building blocks of competitive and dynamic economies. Countries and regions with vibrant innovation and entrepreneurship ecosystems tend to witness higher productivity rates, leading to increased economic growth and more robust job creation, the main pathways through which the poor can escape poverty. As a key driver for firm growth, innovation fosters shared prosperity by stimulating formal employment and increasing wages."[1]

Technology is a key element of evolution and the latest technology which is driving towards a roaring success is blockchain. Blockchain, a form of Distributed Ledger Technology (DLT), brought forth ten years ago and since then it has sufficiently evolved. Not only supports digital currency operations and helped them thrive, but at the same time the researchers and developers brought to the spotlight other uses of the blockchain which changing enterprises' operation and governance.

Blockchain technology which is emerging rapidly with boundless applications in the future, is more than just a technology. Blockchain operates as a value transaction system, software, distributed ledger, etc. In virtue of this host of benefits and features, businesses are

[1] The World Bank/IBRD-IDA "Innovation & Entrepreneurship" [Online]. Available: https://www.worldbank.org/en/topic/innovation-entrepreneurship. [Accessed: 27-Jun-2019].

now changing their traditional centralized working systems and adopting this new trending Distributed Ledger Technology.

In the following chapters, we will present the blockchain technology and how the use of this innovative idea affects and contributes to the growth and expansion of entrepreneurship. In particular, I will present the way this technology operates, its main principles, what are the benefits of its use and what kind of risks might occur. Furthermore I will present its growth path and development by presenting different fields of application that have already been developed and others that haven't been implemented yet. Finally it will be introduced the legislative initiatives taking in the area of the European Union which will help in the development of technology, and support entrepreneurs through programs for innovative actions.

KEY WORDS: BLOCKCHAIN, DISTRIBUTED LEDGER TECHNOLOGY, SMART CONTRACTS, DIGITAL ECONOMY, DIGITAL SOCIETY

Π Ε Ρ Ι Λ Η Ψ Η

Το αντικείμενο της παρούσας διπλωματικής εργασίας επιλέχτηκε ούτως ώστε να καλύπτει και τις δύο πτυχές του μεταπτυχιακού προγράμματος «Ψηφιακή καινοτομία και επιχειρηματικότητα». Η επιχειρηματικότητα και η καινοτομία είναι δύο όροι στενά συνδεδεμένοι μεταξύ τους, οι οποίοι επιδρούν τόσο στην κοινωνική ζωή όσο και στην διακυβέρνηση. Οι νεοσύστατες επιχειρήσεις θωρακίζουν την οικονομία με την επινόηση νέων ιδεών, την ανακάλυψη νέων ευκαιριών και την διοχέτευση πόρων σε αυτές. Από την άλλη, οι ήδη υπάρχουσες επιχειρήσεις καινοτομούν αποσκοπώντας να αντιμετωπίσουν τον ανταγωνισμό. Ενώ στον δημόσιο τομέα, η ανάγκη για αποτελεσματικές πολιτικές για την αντιμετώπιση των νέων προκλήσεων, όπως η ανάγκη για αύξηση της παροχής υπηρεσιών σε συνδυασμό με μείωση των προϋπολογισμών τους, ωφελεί επίσης στην καινοτόμο σκέψη.

Η καινοτομία και η επιχειρηματικότητα αναγνωρίζονται ως βασικά δομικά στοιχεία ανταγωνιστικών και δυναμικών οικονομιών. Οι χώρες και οι περιφέρειες με έντονα οικοσυστήματα καινοτομίας και επιχειρηματικότητας τείνουν να βλέπουν υψηλότερα ποσοστά παραγωγικότητας, οδηγώντας σε αυξημένη οικονομική ανάπτυξη και ισχυρότερη δημιουργία θέσεων εργασίας, δηλαδή τα κυριότερα μονοπάτια μέσα από τα οποία οι φτωχοί μπορούν να ξεφύγουν από τη φτώχεια. Η καινοτομία, ως βασική κινητήρια δύναμη για σταθερή ανάπτυξη, ενθαρρύνει την κοινή ευημερία, προωθώντας την επίσημη απασχόληση και αυξάνοντας τους μισθούς ".

Η τεχνολογία αποτελεί βασικό στοιχείο της εξέλιξης και το είδος που τελευταία έχει κερδίσει μια δημοφιλή αναγνώριση είναι η αλυσίδα συστοιχιών. Η αλυσίδα συστοιχιών, μια μορφή της τεχνολογίας κατανεμημένης εγγραφής, εμφανίστηκε πριν από δέκα χρόνια και έκτοτε έχει εξελιχθεί αρκετά. Όχι μόνο υποστηρίζει την λειτουργία των κρυπτονομισμάτων και τα βοήθησε να ευημερήσουν, αλλά την ίδια στιγμή, οι ερευνητές και οι προγραμματιστές έφεραν στο προσκήνιο νέες χρήσεις της αλυσίδας συστοιχιών που αλλάζουν τον τρόπο λειτουργίας και διακυβέρνησης των επιχειρήσεων.

Η τεχνολογία της αλυσίδας συστοιχιών, η οποία αναπτύσσεται ταχέως με ένα απεριόριστο πεδίο εφαρμογής στο μέλλον, είναι κάτι παραπάνω από μια τεχνολογία. Η αλυσίδα συστοιχιών λειτουργεί ως ένα σύστημα συναλλαγών αξιών, λογισμικό, κατανεμημένο γενικό καθολικό, κλπ. Λόγω αυτής της πληθώρας πλεονεκτημάτων και χαρακτηριστικών, οι εταιρείες αλλάζουν τώρα τα παραδοσιακά κεντρικοποιημένα συστήματα εργασίας τους και υιοθετούν αυτή την νέα τεχνολογία κατανεμημένης εγγραφής.

Στα επόμενα κεφάλαια, θα παρουσιάσω την τεχνολογία αλυσίδας συστοιχιών και πως η χρήση αυτής της καινοτόμου ιδέας, επηρεάζει και συνεισφέρει στην ανάπτυξη και επέκταση της επιχειρηματικότητας. Συγκεκριμένα, θα παρουσιάσω τον τρόπο λειτουργίας της τεχνολογίας, τις βασικές αρχές της, ποια είναι τα πλεονεκτήματα της χρήσης της και ποιοι κίνδυνοι μπορεί να προκύψουν. Επιπλέον θα παρουσιάσω την αναπτυξιακή της πορεία και εξέλιξη μέσω διαφορετικών πεδίων εφαρμογής, τα οποία έχουν ήδη προγραμματιστεί και άλλα που δεν έχουν ακόμη εφαρμοστεί. Τέλος θα προβληθούν οι νομοθετικές πρωτοβουλίες που έχουν αναληφθεί στην Ευρωπαϊκή Ένωση, οι οποίες θα βοηθήσουν στην εξέλιξη της τεχνολογίας και θα στηρίξουν τους επιχειρηματίες μέσω προγραμμάτων καινοτόμων δράσεων.

ΛΕΞΕΙΣ ΚΛΕΙΔΙΑ: ΑΛΥΣΙΔΑ ΣΥΣΤΟΙΧΙΩΝ, ΤΕΧΝΟΛΟΓΙΑ ΚΑΤΑΝΕΜΗΜΕΝΗΣ ΕΓΓΡΑΦΗΣ, ΕΞΥΠΝΑ ΣΥΜΒΟΛΑΙΑ, ΨΗΦΙΑΚΗ ΟΙΚΟΝΟΜΙΑ, ΨΗΦΙΑΚΗ ΚΟΙΝΩΝΙΑ

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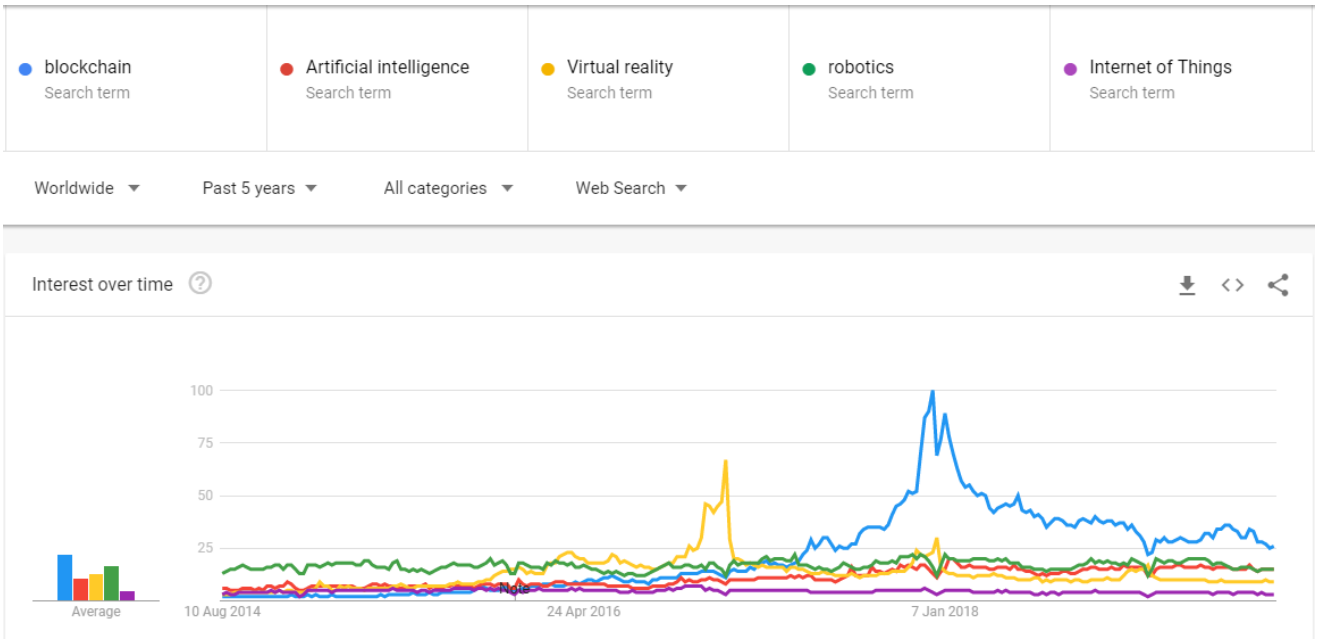
1. INTRODUCTION

Blockchain is a distributed ledger technology which time-stamps all the exchanging data occur in a pear to pear (P2P) network. Any data that once enters this ledger cannot be altered or changed. Everything is stored chronologically and in all computers participating to the network, thus ensuring easy traceability and transparency respectively. Taking a quick view, we could say that we are talking about a new technological accounting system which introduced a true element of innovation regarding transparency and security. The data are not stored in one spot (book, ledger, computer, server, etc) but are distributed to a computer network and each one of these computers are not controlled or maintained by the same person.

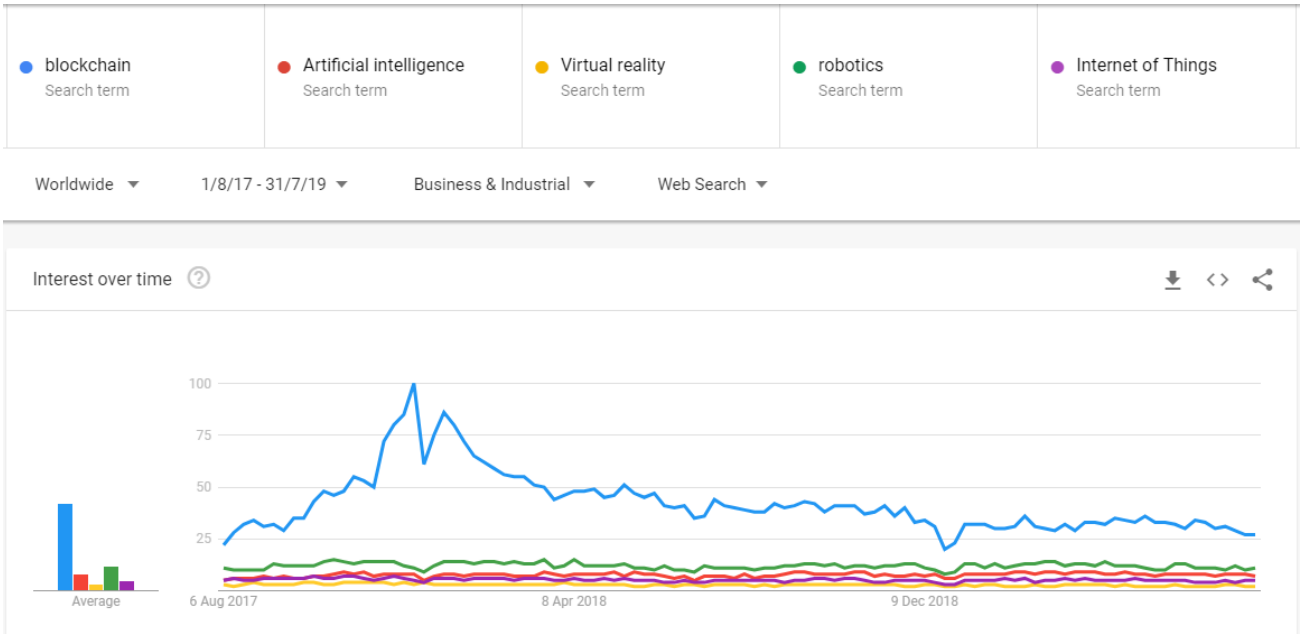
Blockchain together with other emerging technologies such as Artificial Intelligence (AI), Internet of Things (IoT), Robotics, Virtual Reality (VR) are driving the fourth industrial revolution (4IR). Those technologies are going to change the way we live and work and are tightly bonded with innovation and entrepreneurship. To understand the impact of those technologies in economy and business is needed only to mention that the theme of World Economic Forum in Davos in 2016 was "Mastering the 4th Industrial revolution".

According to World Economic Forum, the 4IR "*is characterized by a range of new technologies that are fusing the physical, digital and biological worlds, impacting all disciplines, economies and industries, and even challenging ideas about what it means to be human. The resulting shifts and disruptions mean that we live in a time of great promise and great peril. The world has the potential to connect billions more people to digital networks, dramatically improve the efficiency of organizations and even manage assets in ways that can help regenerate the natural environment.* "

Since all the above mentioned technologies are very popular we needed a tool that would show us where to focus. Using Google trends we wanted to identify the popularity of those technologies' terms among all people and not just academia or business. As you can see in the following picture, the results of the last five years were clearly drove us to examine the blockchain technology.



Using the same terms and making our search more targeted both in time (last two years) and in category (Business and Industrial) it made it clearer that Blockchain technology is by far the most recognized technology and the one that people are mostly linked it with business and industry.



1.1. Scope and Objectives

The scope of this paper is to examine blockchain technology following its evolutionary path and its impact on social and economic development. We set as our first priority to describe the key features and characteristics of its operation in order to understand which of them provide blockchain with a competitive advantage over the existing technologies and make it one of the pioneers of the so-called 4th industrial revolution. Our main focus, however, bounded on the impact of this technology on global socio-economic life and how it will determine and change the way businesses and governments will operate focusing primarily on benefits of adopting Distributing Ledger Technology. On the ground of the aforementioned we aimed to detect those areas that blockchain technology will affect the way people will interact and communicate, like trading, banking, health care, e-governance etc.

Our research objectives are to identify the sectors that mostly will be erapted by distributed ledger technology and through the different use cases which either have already been developed or are still in the theoretical approach, to present the benefits of the new internet era the "Internet of value". As will be clearly seen, all the research material was based on a bibliographic review with the aim of summarizing the conclusions of both the published scientific work and those derived from the use and implementation of such projects.

In order to accomplish the above, in the first chapter we introduce the terms of Blockchain technology and upon which ideas it was named, the key features and the categories of the technology. The second chapter describing the blockchain generations. Chapter's first paragraphs examine the technology based on its first implementation in Bitcoin and through this its basic components and security risks are presented. The following paragraphs introducing the technology's first big evolution through the implementation of Ethereum and smart contracts and some other platforms beyond cryptocurrencies which was born with the advent of smart contracts. In the third chapter we describing the methodology it was followed. In the 4th and 5th chapters we present the technology's benefits through the various use cases which are driving the world in a new era of digital economy and yet to come, the applications which will lead us to a digital society. The 6th chapter introducing what could be blockchain's correlation with other disruptive technologies like Artificial Intelligence and Internet of

Things. Before come to conclusions we introduce the legal initiatives taken to safeguard the smooth development of this innovative technology and what could be the implications if it is not regulated correctly.

1.2. Distributed Ledger Technology

In finance, a ledger account is used to record all accounting transactions related to a specific account. For example, a company's bank account would have a ledger writing down all its transactions. Every time money will be spent or deposited in that account would have to be registered in the ledger. Similarly a "Blockchain Distributed Ledger" keeps the same information related to a series of transactions across multiple computers, forming a peer to peer network. This "strange" idea of hundreds or thousands of computers storing the same transactions it's not stand for redundancy purposes but mainly serves security issues as it ensures there is no central point of failure in the entire system. This kind of infrastructure protects the system from manipulative attempts by participants acting in bad faith. This in turn gives the ability to leave out any middlemen and create a decentralized network.

Taking things ahead, Blockchain is a decentralized database, which is distributed over a computer network, with each computer in that network storing an identical copy of the same database file. De-centralized blockchains based on consensus mechanism or algorithm. These consensus mechanisms or algorithms enable the different network participants (called nodes) to verify any new unique transaction – any transaction can be written only once - and always preserve an updated, ledger's uniform view.

Each new transaction is verified, ordered and grouped into blocks which are then ciphered and linked to the previous blocks. Every new block is built on top of the previous one in chronological order. The best example to explain is by representing blockchain with a book. Each page of the book is the blocks. Each page (block) includes different transactions and of course not all pages include the same amount of transactions. Whoever node needs to attach a new page, must do it by taking in mind the page number of the previous page. So nobody can

create page number 51 if the page number 50 hasn't been attached to the book. This number in blockchain blocks is called a nonce.

Blockchain also makes sure that the information is not stored at a central location, rather gets spread in the network. This means that any node has a copy of the book stored in its system. So if someone would like to change the data (changing book's story) he has to change all previous pages not only from his copy but from others too. In fact he will need to change it in more than 51% of the nodes, but this is something it will be explained in more details in next chapter.

As it is obvious, blocks are a type of data structure containing information and more precisely transaction records. Generally distributed databases can contain any kind of data and not just financial or economic data but block chain security and design made it especially suitable to use for value exchanges. Blockchain technology looks like is going to change the internet as we know it today and transform it from information sharing to value sharing. That is why blockchain networks are named as the "Internet of Money" or "Internet of Value"

1.3. Blockchain key Features

By technically examining blockchain technology, we can identify four main features

I. Decentralization
II. Traceability
III. Immutability
IV. Value properties

Decentralization includes all those processes needed to be executed from all system peers, in order transactions to be verified, storage and transited, as well as those for the system structure maintenance. Since there is no central authority to verify each transaction, the trust between peers is based on complicated mathematical methods.

Traceability stands for the ability to anyone participating in the system to find any transaction stored in blocks by examining the block information linked by hash keys. As it was mentioned before, all transactions in the block are arranged in chronological order and each block is connected with its two neighboring blocks by cryptographic hash function.

Blockchain immutability is grounded on two factors. The first one it has to do with the use of hash functions. Since each block is connected with its neighboring blocks through hash functions, there is one hash key linking it with the previous block and another one pointing to the next one. Tampering of any transaction would lead to different hash value, so all other peers who runs the same validation algorithm, would identify that something goes wrong. The second factor is linked to the structure itself, as all information is shareable and stored in all nodes which are sync in real time. In order so to change or hack the system successfully, you will need to do it for more than 51% of the peers (nodes) connected to the system

Blockchain technology is tightly bonded with cryptocurrency. Needless to mention, that any blockchain network includes a form of cryptocurrency value. Even though no third-party is involved, circulation of digital currency is predefined, thus is created by using a specific mining algorithm and is bounded by a pre-defined formula. Therefore the risk of problems like inflation and collapse are eliminated. In Blockchain 2.0 and 3.0 applications, the services or activities transferred through the network could be represented by the property of value.

As an outcome of those technical features blockchain technology is inherited with some advantages which are crucial since antiquity for the success of any trading business, either this is money or any other assets. Those are:

Reliability: Blockchain decentralized nature offers transparency since transactions are not stored in one place and everybody can check them. Furthermore, applications built on blockchain technology ensure high reliability, as they continue to work even when some of its nodes go under failure.

Trust: The same as with reliability, blockchain network is spreading the trust to all nodes. Unlike the centralized systems where trust is taken for granted, such as governments or central banks, in blockchain applications the same copy of ledger is shared to every network

peer. In fact trust is delegated to blockchain technology and not to a person, an organization or a group of them.

Security: It is based on mathematical functions mainly used in cryptography, and others developed to achieve consensus among the network users. Due to those mechanisms data even though are distributed publicly to all nodes cannot be altered. In addition the whole infrastructure doesn't have a single point of failure, thus making difficult to hack

Efficiency: Every transaction automatically goes through predefined procedures. Therefore, benefits all sectors is being used to establish faster procedures, reduce paperwork and labor cost. One of the biggest advantages blockchain inherited to business is cutting off middlemen

1.4. Blockchain categories

Block chains are mainly classified into two categories. The distinction comes from the network infrastructure owner. It is similar to the distinction between the internet and Intranet.

a) public or permissionless and

b) private or permissioned

The first type is a public network which everyone with the right hardware and software can join, as it goes nowadays with the famous crypto assets (Bitcoin, Ethereum). Anyone being part of the blockchain can either just conduct transactions or actively involved to the consensus process in order the network to be more advanced. In this case the most benefits, as it was summarized before, come from decentralization. The system users don't need any intermediary to conclude their transactions making them faster, cheaper and more secure. Similar process nowadays involves multiple steps and intermediaries which makes it expensive and time consuming.

The second type belongs or managed by an organization or a consortium and can be accessed only by those given the right permission to use it. It looks similar to organizations

databases and its main target to some extent, is to eliminate fraud and/or reduce time of some procedures. Despite the fact that it's still a distributed computer system many large financial institutions and other corporations are actively developing such private block chains to streamline their operations and benefit from the efficiency that block chain architecture brings, maintaining in parallel the privacy is still required for their internal operations. A great example is banks which are obliged to perform a careful due diligence of their clients to prevent money laundering and terrorism financing. Two or more banks could come to an agreement and built their own private blockchain, where the data for each of their customers could be stored (Know Your Customer) and accessed by all participants. In that way due diligence would be faster and more accurate. To go one step further, if also the State regulator or authorities could access this blockchain, then a more transparent banking system could be created.

Another classification for blockchain technology could be derived from its development all these years. It is defined three categories or stages, Blockchain 1.0, 2.0, and 3.0.

a) Blockchain 1.0 is the beginning of digital money distribution and the establishment of a new money transfer system without central authorities.

b) Blockchain 2.0 are those applications dealing with more complex transactions. In this category are included applications for stocks, bonds, loans, smart property, and smart contacts.

c) Blockchain 3.0 goes far more than finance and economy. Blockchain is entering in areas like governance, health, art and in peoples' social life.

2. BLOCKCHAIN GENERATIONS

2.1. First Generation

Blockchain technology was made know to wider audience because of its use in Cryptocurrencies. Bitcoin was the first digital currency built over Distributed Ledger Technology, allowing its users to make transactions without the need of a financial institute. Even though Bitcoin was published in 31/10/2008 by Shatoshi Nakamoto as a *"pear to pear electronic cash system"*[2], we need to notice that definitions of "proof of work", "timestamping of digital documents" or "digital currency" have been already introduced many years before Shatoshi's paper. Another point needs to be highlighted from Shatoshi's paper on Bitcoin, is that he never used the term blockchain. In fact this is a term populated later.

Bitcoin except being the first cryptocurrency is by far the most acceptable and successful. What is more, any kind of development and new ideas regarding blockchain technology had as a starting point Bitcoin's implementation. Wouldn't be far from reality to say that bitcoin blockchain contributed the most, together with artificial intelligence, to the faster evolution of digital technology that leads us to the 4th industrial revolution. So the best way to understand the core values of blockchain operation and how this technology drove entrepreneurs to new innovative paths is to go through the basic implementation of bitcoin.

2.2. Peer to Peer Network

The key element of blockchain is indeed its ability to allow transactions without the interference of any middlemen. Financial transactions realistically, are messages transmitting over a communication network. This is how money is transferred from one's bank account to another bank account. The unique thing that blockchain brought was its structured as a peer to peer network. These network participants or peers are referred as nodes. On top of the internet,

[2] Satoshi Nakamato, "Bitcoin: A Peer-toPeer Electronic Cash System," pp. 1–9, 2013.

all those who want to be part of the blockchain network, so called the network nodes, run a protocol (software) which for Bitcoin is bitcoin protocol. Node of the network can be any PC, phone or table regardless its technical specifications (operating system, cpu, disk memory, etc). This is a general rule as there are some roles in blockchain network like mining (creation of new blocks) that need big computation power and substantial resources and cannot be performed by phones. What all nodes can do is send and receives transactions, verify transactions and keep a full or partial copy of ledger's database.

What we need to behold is the deference between the nodes who store the full ledger's copy, thus all transactions from the initial one, or a part of the ledger that is necessary to verify any new transaction. The first are called full nodes and the second one lightweight nodes or SPV nodes, meaning Simplified Payment Verification nodes.

Full nodes have the ability to track all coins created from the very beginning and verify the transaction. Since they have full historical records of all transactions they know when a coin was created, where it was spent, in which transactions it was involved, who owned it in the past and who is its current owner. To put things in its right order, cryptocurrencies accounts are just address, similar to those we use in the web to reach a site. So what is written in blockchain database is not the owner's real name but just an address. That is why they called pseudonymous and one of the main reasons bitcoin became very famous in criminals. The accounts are ciphered and only who has the cipher key can open it.

On the other hand lightweight nodes, simply because they are lacking storage space, they keep only the headers of all blocks. When they need to verify a transaction, they simply check in which block the transaction was included and if on top of this block at least six blocks are built. As a matter of fact, lightweight nodes rely on the work done by full nodes in order to avoid double spending.

Some nodes, except the above actions, are involved with the mining function which de facto is the most crucial service, as it involves the calculation of the blocks which are going to be part of the chain.

2.3. Confidentiality and Privacy

One of the main concerns in an open network is that nobody unauthorized could change or delete a transaction. For that reason Blockchain is using cryptography in order to maximize its confidentiality and privacy. Cryptography is a math-based science for coding and decoding data. Encryption methods make sensitive data accessible only to those who are appropriately empowered. This ensures the confidentiality of digital communications and the storage of sensitive information. In particular Bitcoin blockchain includes cryptographic techniques such as asymmetric cryptography, hash functions and digital signatures.

Those cryptographic solutions were introduced by Satoshi in his paper as follows: "*We define an electronic coin as a chain of digital signatures. Each owner transfers the coin to the next by digitally signing a hash of the previous transaction and the public key of the next owner and adding these to the end of the coin. A pay can verify the signatures to verify the chain of ownership*[3] "

2.3.1. *Asymmetric Cryptography*

In asymmetric cryptography, different keys are used for encryption and decryption, a public key and private one respectively, which must have the following properties. Those messages encrypted with a specific public key can be only decrypted with the corresponding private key and vice versa. Knowing the public key, the private cannot be found in a simple way.

In cryptocurrency blockchains each user has a pair of keys, a public and a private one which enable transactions on the network. The public key is used by the sender to encrypt information regarding the transaction which can then be decrypted only by the receiver with his or her corresponding private key. The public key can be shared openly as it serves like an address or account which can only receive funds.

[3] Satoshi Nakamato, "Bitcoin: A Peer-toPeer Electronic Cash System," pp. 1–9, 2013.

We need to notice at this point that since there is no central authority on the network that can reverse transactions or restore private keys; the private key must be stored securely and never be disclosed. User's private key is the only one giving access to his funds. Supposedly, a private key is lost automatically user's funds is lost permanently there is no such thing as a password reset function on the block chain. Users need to take responsibility for storing and backing up properly their private keys because there is no central authority on the network that can reverse misplace transactions or restore private keys.

2.3.2. Digital Signatures

With the previous paragraph process, we actually ensure that from the initial encryption to the final reception and decryption of the message, this has not been read or altered by a third party. But how can we be sure, since public keys are available to everybody, that indeed the sender is the one who claims in his message that he is? How could we exclude the possibility that the message hasn't been encrypted by a malicious third party?

For that reason, another cryptographic technique used in blockchain is digital signatures. Digital signatures are based in asymmetric cryptography but they are created using the opposite process. The sender creates his digital signature with his private key and the resulting code output is then attached to the signed message and acts like a signature. The receiver certifies the message's owner with his public key.

Digital signatures giving additional security benefits to blockchain network:

Origin authentication: The receiver is certain about the sender's identity

Integrity: The recipient can verify after receiving the message that it wasn't modified during transmission

Non-repudiation: The sender cannot refuse retrospectively that he has sent or signed a message.

This last property is one of the most significant allowing bitcoin and any decentralized system to operate smoothly, as there are no intermediaries and central authorities. Since this process includes mathematical calculations it is impossible to generate a valid signature for a party without knowing that party's private key. Furthermore digital signatures cannot be intercepted and modified or reproduced while in transit. They are also non-reusable as they cannot be separated from a transaction message and used to a different message, given the fact that the algorithm creates a new signature for each transaction.

2.3.3. Hash Function

In order the principle of confidentiality to be ensured, blockchain is using the hash function mechanism to hide users' identities and create a so called pseudo-anonymized account. Hash functions are also used to create the digital signatures of each block in the network, thus guaranteed transactions integrity.

Hash functions are mathematical functions that are used to convert input data of any length into a compressed unique fixed length string of characters. This output data (hash value) serves as a unique reference code or digital fingerprint to verify the authenticity of some underlying data set, without the need to actually check the entire data set. When applied to a given dataset, it fabricates a unique outcome and the possibility two different data sets to be resulted with the same hash, is extremely low.

Another benefit from the use of hash functions is that blockchain data can be somehow standardized and rationalized. As it was mentioned previously, all nodes in the network keep an identical copy of all transactions and blocks vary in size. This is because one block may have four hundred (400) transactions while others one thousand (1000). Take also into account that those transactions may different on the size of information attached to them. In terms of kilobytes the only capacity limit in the bitcoin block chain protocol is in the size of each block which has been one megabytes since 2010. It was recently amended to effectively 1.4 megabytes with the latest upgrade of the Bitcoin software. But again block sizes can vary up to that limit.

By using hash functions the verifying procedure is getting more efficient as we don't need to verify all block transactions but just the hash results of it. The hash output size depends on the algorithm used, but what is important to remember is that always resulted to the same size no matter the input size. While we always use the same hash algorithm, the hash value will be always different because the inputs are different.

Hash functions are designed to be one way functions, meaning that cannot be inverted and recalculated backwards to get the input data. The only way to recreate the input data, if one has the output only, is by a brute force search of all possible inputs. That basically means to try systematically all possible combinations that will lead him to the given result. Something similar is taking place in the proof of work blockchain consensus algorithm that will be examined later.

2.4. Consensus mechanisms

"A fundamental problem in distributed computing and multi-agent systems is to achieve overall system reliability in the presence of a number of faulty processes. This often requires processes to agree on some data value that is needed during computation".[4]

This process is called consensus and different algorithms or mechanisms were created in order to be achieved. Consensus main work is to immunize the system from any fault tolerance, hence being resilient to nodes failures, corrupted transactions and delayed or out of order messages. By establishing consensus mechanisms, network participants ensured that all nodes are automatically updated thus all system nodes have the same input and all of them will produce the same outcome.

This problem, known as Byzantine Generals Fault tolerance, concerned developers for many years and was a subject of, mainly academic, research. Nakamoto was the first applied a consensus algorithm to a live decentralized system. The solution Nakamoto proposed is

[4] en.wikipedia.org, "Consensus_(computer_science)." [Online]. Available: https://en.wikipedia.org/wiki/Consensus_(computer_science). [Accessed: 27-Jun-2019].

called Proof of Work (PoW) and is based on the power contribution of a node to solve a mathematical problem. Bitcoin implementation it didn't only change our financial transaction perception but gave the opportunity to the rest of mechanisms attached to it to be further evolved and bring new solutions that could be adopted to other applications

As it was explained in the first chapter, blockchain setup is categorized to permissionless and permissioned. Permissionless are open to everyone so it is expected to have plenty of nodes which of course are anonymous and with lack of trust to each other meaning that more strict rules in case of consensus must be established. On the other hand users of a permissioned blockchain platform are known since before entering the system need to be verified and registered. Each platform was created in order to confront different real life problems such as immediate transactions, scalability and low latencies and for that reason they followed a different approach in the consensus model they applied.

2.4.1. Proof of work

Transactions are not distributed over the network one by one. First are grouped to a block and before this block being part of the blockchain, a difficult mathematical problem needs to be solved. In Bitcoin the puzzle nodes need to solve, includes the calculation of a hash value starting with a minimum numbers of zeros which constitutes the network's difficulty level. The hardness level is changed by the bitcoin protocol in a way that one block will be created every ten minutes.

Nowadays is well known that mining needs quite big amount of resources (computation power, electricity) in order users to be competitive and be the first one who will be rewarded by solving the puzzle. If it is so, then we reach to the conclusion that the node with the biggest availability on resources would always be the winner. Actually, not always the strongest computer wins. This happens because every block includes a special random number which when added to the calculation makes the calculated hash completely different. So you have to try many numbers before managing to find the one that gives you an acceptable hash. The

number that it was used to create the right hash is included in the block and is called a Nonce. That is why you need more time to calculate a new block than checking one.

The first miner who manages to solve the puzzle gets the right to publish the block, as proof of work and is rewarded for his success. This process is called mining and big computation power is needed to be spent by a peer, in order this puzzle to be solved. Since we are talking for a decentralized system with plenty of users, there are cases that two of the users could reach to an acceptable result. Both of them will publish their block and the rest of the nodes will continue to build new blocks which some will be linked on top of the one block and some on top of the other. This will create a temporary phenomenon called fork as from the main chain two branches are created. Finally the protocol will accept the branch which collected the most of the blocks as the most power of work is concentrated on it. Unfortunately the rest of the blocks will be rejected and the transactions were written on them need to be added to a new block.

Even though Bitcoin operates completely decentralized and has an excellent scalability because of its consensus mechanism, however PoW has some disadvantages like energy expenditure and cost, low transaction rate and high latencies, making it less suitable for many applications. For that reason newer blockchain platforms like Ethereum tried to apply PoW in a different way. As an example one of the techniques used to prove power of work is called memory hardness and is calculated based on computer's ability to move data around in memory rather than perform calculations.

2.4.2. Proof of Stake

Unlike bitcoin proof of work, in this mechanism users must invest their stake. The one who invests the biggest stake is the winner, thus the one who will add the next block to the chain. The biggest stake invested, biggest are the odds to be chosen as the one who will create the next block. Analogous is of course the risk undertaken to lose part of his investment. This is resulted because proof of stake algorithm chooses winners pseudo randomly so it isn't certain that their block will be selected to be built in the existing chain.

This new mechanism was introduced in order to minimize the problems of expensive electricity consumption which appears in proof of work, scalability, security and decentralization improvement. Unfortunately this doesn't come without any disadvantages. For example what will happen when someone invest something he doesn't possess? The so called "Nothing to Stake" problem could happen when a node will invest its stake in two blocks in order to win in any case. Since no measures were introduced against the fraudsters nothing could prevent them from trying. This kind of problem is met on PoS algorithms where users have the ability after some period of time to remove their security investment from a block.

Ethereum was of the first Blockchain platforms who wanted to integrate to its platform the proof of Stake mechanism. The best solution was the Casper protocol which has been proposed by an Ethereum developer in 2017. The Casper protocol implementation was a great solution to come up also against the Nothing to Stake problem. Casper friendly ghost as is known, is a contract which detect the nodes with the significant security deposits to the Ethereum protocol. Those nodes are consist the list of bonded validators. This list is updated according to the nodes behavior, as some new are created and some others are leaving the system.

The bonded validators are those who pseudo randomly chosen to produce the new blocks. In case someone is offline a new one is selected. For those nodes their blocks included in the chain, they receive as reward based on the total tokens of the active validators list. On the opposite, those nodes who don't manage to publish their blocks are losing part of their security deposit which is equal to the reward it would had been given in case of winning. This algorithm preventing nodes from producing blocks that won't be accepted in the main chain and solves the "Nothing to Stake' problem.

2.4.3. Practical Byzantine Fault Tolerance

Practical Byzantine Fault Tolerance is a consensus algorithm introduced in the late 90s by Barbara Liskov and Miguel Castro. Byzantine Fault Tolerance (BFT) is the ability of a distributed network to reach to an agreement on a given value, even if some of the network nodes fail to respond or transmit the wrong information.

Byzantine Fault Tolerance mechanism uses a collective decision making in order to minimize the influence of problematic nodes, thus protecting the system from failures. BFT is derived from Byzantine Generals' Problem. The problem was explained in a paper by Leslie Lamport, Robert Shostak, and Marshall Pease at Microsoft Research in 1982:

"*Imagine that several divisions of the Byzantine army are camped outside an enemy city, each division commanded by its own general. The generals can communicate with one another only by messenger. After observing the enemy, they must decide upon a common plan of action. However, some of the generals may be traitors, trying to prevent the loyal generals from reaching an agreement. The generals must decide on when to attack the city, but they need a strong majority of their army to attack at the same time. The generals must have an algorithm to guarantee that (a) all loyal generals decide upon the same plan of action, and (b) a small number of traitors cannot cause the loyal generals to adopt a bad plan. The loyal generals will all do what the algorithm says they should, but the traitors may do anything they wish. The algorithm must guarantee condition (a) regardless of what the traitors do. The loyal generals should not only reach agreement, but should agree upon a reasonable plan.*"

Consensus can be achieved when the nodes who work correctly can reach an agreement regarding their values. It is consider that some of the nodes are working properly while some others not. In order to distinguish them a default vote value is determined on the messages that would be count as missing. For example faulty will be those messages that would not be received in a given period of time

PBFT mechanism needs less energy since it can reach distributed consensus without carrying out complex mathematical computations like in PoW. In addition, transactions do not

require multiple confirmations like in case of Bitcoin implementation where every node individually verifies all the transactions.

PBFT tries to provide a practical Byzantine state machine replication that can work even when malicious nodes are operating in the system. Nodes are sequentially ordered with one node being the primary (or the leader node) and others referred to as secondary (or the backup nodes). It is noted that any node in the system can become the primary by transitioning from secondary to primary. This is the case when a failure in a primary node occur. A practical Byzantine Fault Tolerant system can function on the condition that the maximum number of malicious nodes must not be greater than or equal to one-third of all the nodes in the system. As the number of nodes increase, the system becomes more secure.

PBFT consensus mechanism can be separated in four steps. The client transmits its demand to the leader node who in turn forward it to all secondary nodes. Both leader node and the secondary ones execute the actions requested and send back to the client their answers. Client's initial demand will be considered successful when the total number of replies containing the same result and coming from different nodes of the system, will be grater of the maximum faulty nodes allowed in the system.

2.4.4. Proof of Elapsed Time

Intel was the one who proposed this consensus mechanism which uses low computing power based on the utilization of Intel's trusted computing platform. Its characteristic is that the next block builder is chosen randomly by the algorithm grounded on waiting time. In fact each node runs the algorithm and a waiting time is defined. The node with the shortest waiting time wins and when this time is completed, can finalize the blog. Because of its randomness in nodes selection, it offers a fairness blockchain network.

To achieve consensus right performance, the procedure needs to be justified. This is succeeded with the creation by the elected node of a proof that is easy to be validated by the rest of the nodes. Two are the important elements algorithm needs to secure. The first is that

indeed the waiting time for the selected node was randomly created and the second is that the node waited for the determined time.

2.4.5. Proof of Authority

This is a consensus algorithm allowing the network to conclude a transaction faster. The concept of Proof of Authority consensus, as its name indicate, is that only authorized nodes is allowed to approve transactions and built new blocks. Nodes taking part in the network gain reputation and when its reputation reach in a high level then it can take the role of validator. Proof of Authority it is assumed a more robust consensus algorithm than proof of stake, because of the following reasons. The first is that validator nodes based on the reputation they receive by contacting legitimate transactions and there is no other way to change it. In Proof of Stake you can invest more of your stake and the possibilities to be the next validator are increased. The second reason is that none of the nodes can be a validator of two consecutive blocks.

2.5. Blockchain Security

When we are talking about blockchain the first thing coming to our minds is security which is the most appealing attribute of the technology. Its security mechanism is grounded on holistic distribution among all nodes of both the ledger and consensus. As it happens with all digital systems, blockchain highly security mechanism does not mean that it can stand up to any type of fraud or hacking attack. Since blockchain networks are mainly used to record transactions of value or data, it goes without saying that the majority of the users are worried about the security. According to Rui Zhang, Rui Xue and Ling Liu the security and privacy requirements for online transactions are categorized as follows

i. Consistency of the ledger across institutions. Each institution need to keep his own ledger with all transactions. At the end of the day all accounts that are kept in both financial institutions must conclude to the same result.

ii. Integrity of transactions: In order online transactions to be fulfilled it is needed personal data and identifiers to be transferred. The system which will be used for such transactions must guarantee that any tampering actions will be prevented.

iii. Availability of system and data: System should be accessible at any time from everywhere. Availability must cover both the system and the transactions level.

iv. Prevention of double spending: This means that the system should place appropriate mechanisms that will not allow money that have already been spent, to be used as a whole or part of them, for another transaction.

v. Confidentiality of transactions: Users of financial transactions want to be sure that their transaction information cannot be seen by unauthorized people and by all means all his data would be securely stored even under unexpected failures or hacking attempts.

vi. Anonymity: The system will settle on methods to offer anonymity to the user and his data will be revealed after his agreement.

vii. Unlinkability of Transactions: The transactions of the same user should not be linked to each other, as to protect other background data of the user's personality

Blockchain security features derive from its design and implementation as well as features inherited by cryptography. The blockchain is built in such a way that security attributes like consistency, tamper-resistant, resistance to a Distributed Denial-of-Service (DDoS) attack, pseudonymity, and resistance to double-spending attack could be guaranteed. Admittedly, everything exposed to the internet isn't totally secure and for that reason extra measures are required or need to be ensured.

Blockchain technology covers mostly all seven categories of security and privacy requirements introduced above. I am saying mostly because there are some different opinions regarding the level of security and privacy on some of the blockchain features. Rui Zhang, Rui

Xue and Ling Liu for example in their paper for Security and Privacy on Blockchain argued that blockchain system should be enhanced by other cryptographic techniques in order to achieve fully anonymity. Based on their analysis, concluded that bitcoin offers pseudonymity but not unlinkability. On the basis of this reasoning, they also support that confidentiality of transactions and data privacy are not fully covered.

As we saw in the previous paragraphs, consistency and integrity are key elements in blockchain implementation. In the next pages we will introduced the most common security problems of blockchain.

2.5.1. Resistance to DDoS Attacks

DDos is stand for denial-of-service and is a cyber-attack in which the attacker attempting to render a machine or a network resource unavailable to its meant users by temporarily or unlimited time disrupting services of a site connected to the Internet. Denial of service is usually fulfilled by bombing the targeted website with unneeded requests, targeting to overload its systems in order to make it impossible to serve even the legitimate ones.

The attack could be originated from many disparate sources distributed over the Internet. The hacker may compromise and use for that reason devices which are connected to the internet and most commonly other people's computers. Taking advantage of a number of compromised systems, a DDoS attacker has the ability to canalize simultaneously a huge amount of requests towards a hosting website address. As the website cannot serve all the requests it is difficult to forestall the attack by just blocking the individual sources one by one.

In regard to blockchain, the success of the attacker will depend on the number of nodes he will manage to put out of order. The number of those nodes must be way more than those continue to work normal in the network. Blockchain technology lacks a single point of failure and for that reason the attacker must to compromise many different entities. This means that he will need huge computation power.

The decentralized form of blockchain allows it to continue operate even when some of its peers is not working. The working peers will continue to create new blocks and validate transactions and the only will be disturb from the whole situation would be only those nodes having the attack. I could say that there might be a possibility such attacks to be successful but it could happen only to permission blockchain with small number of peers and naïve implementation.

To be more specific, in case a permission blockchain has only one or two certification authorities then the attacker might attack these locations and nobody new could enter the network. Even in this situation, it is not certain if the existing peers would have a problem in their operation as it would depend of the role the certification authorities have in the network.

In any case, blockchain technology is resistant to DDos attacks and the larger the network the harder would be for the hacker or hackers to succeed.

2.5.2. Double-Spending Attacks

A well-known security concern for digital currency transactions is the so called double spending. Double-spending occurs when someone makes more than one payment using one body of funds. Undoubtedly double spending of digital tokens should be for genuine concern but as it was explain in the beginning, blockchain transactions are not referred only to digital money but it could be any form of digitize data. So the double spending is a general meaning and not just for money.

Double spending could happen when somebody will use the same digital token to two different transactions. It will make some of us wonder how this is possible since all transactions are recorded and verified. First of all we need to keep in mind that in blockchain there is no central authority to correct any mistake. Indeed all transactions are recorded and all nodes keep a ledger with all the transactions in order to keep control. The problem is possible to occur when there are delays in the verification process. A transaction is broadcast in the network und

before being verified another one is broadcast again including all or part of the funds used in the previous one.

Bitcoin to tackle double-spending, uses a proof of work consensus algorithm, obliging peers to solve a very difficult mathematical problem as to be allowed to publish the transaction. The problem is so complex that it needs about ten minutes to be solved. So each new block with new transactions, which is called mining, is produced every ten minutes. We explained earlier that bitcoin implementation makes mining very hard while verification process is very quick. From the one side this 10 minutes time seems to be enough to avoid such errors while on the other side mining is quite expensive discouraging fraudulent actions.

What is more, all transactions are justified by its sender by using his personal digital signature which warrant that any falsifies a transaction it could be easily detected. The combination of all the above guarantees that Bitcoin blockchain can be resistant to the double-spending attack.

2.5.3. Majority (51%) Consensus Attack

It is the most important security issue of the blockchain and is imputed to the risk of cheating in the majority consensus protocol. Consensus mechanism requires the majority of the peers to accept a transaction as legitimate. Talking in voting terms, the transaction will need more than 50% of votes in order to be accepted. In fact every peer is not counted as one vote. The voting percentage is calculated on the basis of computing activity on the network in terms of the hash rate. If there is a node who controls more than 50% of the hash rate then it can manipulate any transaction.

Another example of the 51% attack may happen when a group of miners collude to perform a conspiracy. Most probably such attacks could be launched in a blockchain fork which happen when two different blocks fighting which will be verified. Because the majority of mining power on the network would support the attackers block, it would be the one sent to the blockchain.

2.5.4. Private Key Attack

It is referred to an attack where somebody will try to hack users' digital signatures and then he could use it to create some transactions and still the person's revenue. As it was presented in order a digital signature to be crated, the private key of the owner is needed. This attack is referred to the attempt to hack someone's private key and not steal it. The only possibility of private keys being hacked comes from the threat of quantum computers.

Quantum computing takes advantage of quantum bits or "qubits" that can exist in any number of values between 0 and 1. That means that quantum computers can process much more information than just binary computation, which is the limit of classical computing systems today. Any hacker could take advantage of this huge power and through a brute force attack will manage to retrieve the private key. If something like this become a reality, this wouldn't be a problem for private keys but a grave threat to almost all cybersecurity aspects. Fortunately this threat is placed in the distance future and until then hopefully countermeasures for such attacks will be developed

2.6. Second Generation

The moment most of the people were seeing in Bitcoin just digital wallets and currencies, there were some who understood that underneath the building blocks architecture, there was a fundamental technological layer that could be used to create many other useful applications. Indeed Bitcoin was originally designed as a payment system but its baseline technologies made it perfect for the demonstration of a proof of ownership system.

You can imagine it, as an open digital notary where any asset, external to blockchain network, could be digitalized and trade on it through a smart contract. In that way blockchain technology can be an effective and efficient solution for real estate property, shareholder registers and other investment securities registers. Of course it could be used also for other

kind of assets or property rights like trademarks and intellectual property. All these don't have to be traded in the same blockchain network, but for each one of them a separate Distributed Ledger network could be created.

One of the first benefits seen in blockchain was the absence of middlemen's that could change totally the trade finance as we know it. Nowadays, trade finance is managed by third parties, such international banks, that both the retailer and the manufacturer are trusting. Both parties to this transaction need security and assurance that they will get what they expect out of it. International banks offer financial services through escrow accounts and letters of credit. *"An escrow account is an account where funds are held in trust whilst two or more parties complete a transaction. The funds will be disbursed to the merchant after they have fulfilled the escrow agreement. If the merchant fails to deliver their obligation, then the funds are returned to the buyer*.[5]"

As it is obvious, both retailer's and manufacturer's businesses are depend on an intermediary who has the power to manipulate the trading in favor of a specific entity. If something like this happen, large organizations may end up monopolizing the trade channel and transform themselves to gatekeepers in the business value chain.

With the advent of blockchain technology, this kind of finance services can be managed through a smart contact and make the procedure faster, cheaper, safer and more transparent. A single technological interface, especially an open source like bitcoin blockchain, which won't be controlled by any third entity, will establish a direct interaction between buyers and sellers thus eliminating any potential rent seeking behavior by intermediaries.

[5] "What is an escrow account?," Escrow.com. [Online]. Available: https://www.escrow.com/what-is-an-escrow-account. [Accessed: 27-Jun-2019].

2.6.1. ETHERIOUM

We analyzed previously how bitcoin's initial idea gave the opportunity, after being widespread, to think beyond cryptocurrencies to a new generation of applications not just for payments but to asset transfer through smart contracts. This kind of services was introduced more extensively with the creation of Ethereum network.

The new theory for the use of distributed ledger technology was introduced in 2013 and its founders vision were to create a decentralized global computer which would be working based on the same fundamental principles and technologies underpinning Bitcoin blockchain; cryptography, proof of work, decentralized consensus mechanism, peer to peer network and software codebase. Ethereum paper reads:

"*Satoshi Nakamoto's development of Bitcoin in 2009 has often been hailed as a radical development in money and currency, being the first example of a digital asset which simultaneously has no backing or intrinsic value and no centralized issuer or controller. However, another - arguably more important - part of the Bitcoin experiment is the underlying blockchain technology as a tool of distributed consensus, and attention is rapidly starting to shift to this other aspect of Bitcoin. Commonly cited alternative applications of blockchain technology include using on-blockchain digital assets to represent custom currencies and financial instruments (colored coins), the ownership of an underlying physical device (smart property), non-fungible assets such as domain names (Namecoin), as well as more complex applications involving having digital assets being directly controlled by a piece of code implementing arbitrary rules (smart contracts) or even blockchain-based decentralized autonomous organizations (DAOs). What Ethereum intends to provide is a blockchain with a built-in fully fledged Turing-complete programming language that can be used to create "contracts" that can be used to encode arbitrary state transition functions, allowing users to create any of the systems described above, as well as many others that we have not yet imagined, simply by writing up the logic in a few lines of code*"[6].

[6] Vitalik Buterin, "a Next Generation Smart Contract & Decentralized Application Platform," no. January, pp. 1–36, 2009.

The paper presented that blockchain technology has many potential use cases far away from cryptocurrencies. As it was mentioned previously those ideas had already introduced and explored. However all studies of those projects were based on bitcoin's blockchain infrastructure, rules and protocols, which as it was proved, were less suitable for those purposes. Ethereum was the beginning of the second blockchain generation (Blockchain 2.0)

The paper is introducing the definition of smart property. The digitalized assets are now referred as smart property. That means that any physical asset like gold, real estate, stocks, bonds, art and so on can be represented by a token on the blockchain. Based on that admission, smart property can be transferred from one person to another by including it in smart contracts and when certain conditions are met. Those details would be fully and easily be determined in the smart contract, simply by writing a few lines code.

Ethereum similarly to bitcoin is a public distributed ledger platform which uses a mining procedure for the creation of blocks. The miners are rewarded for their work with the Ethereum token called Ether. The key innovation though introduced by Ethereum, that differentiated it by Bitcoin and other cryptocurrencies, is its turing complete programming language called Solidity. Turing complete means that Ethereum programming language can be used for the creation of different programming code and run almost any function or task. This exact feature, gives the advantage for broader decentralized applications to be deployed while smart contracts enable the creation of a more complex financial instruments.

Most of Ethereum clients are mainly developed by Ethereum Foundation but there are also other community developers who create a few. Ethereum nodes can be simulated as usual virtual machines since the users are allowed to execute Ethereum programs on their local machines. Ethereum provides to developers a set of tools to innovate further and build their applications and businesses on the Ethereum blockchain. In parallel facilitate the creation of custom digital assets as anyone can launch its own project using the open source of Ethereum protocol. Its infrastructure serves as the backbone of an entire economic and social ecosystem. This is why the majority of blockchain applications were built on Ethereum platform.

2.6.2. HYPERLEDGER

The Hyper Ledger project is a cross industry block chain collaboration launched by the Linux Foundation in December 2015. It focuses on block chain industrial solutions for finance, banking, the Internet of Things, supply chains, health care, manufacturing technology and other sectors. Currently it has over 190 member organizations including industry leaders like IBM, Intel, American Express, Daimler, Airbus, Fujitsu, Cisco Accenture and JP Morgan among others.

Hyper Ledger is an umbrella project which incubates separate block chain projects focused on distinct industrial use cases and solutions. Hyper Ledger projects are built to address specific business models and their issues. They are aimed to be a plug and play solution in order to boost the business performance of consortium members. All components of the hyper Ledger ecosystem are designed to be interoperable, thus they can connect with any other component within the same framework.

Hyper Ledger provides the underlying open source software on top of which anyone can set up apps to meet business needs. Despite Hyperledger is an open source collaboration its target is to build industrial applications which are meant to be deployed in private permission blockchains. Its design philosophy follows a modular approach that enables extensibility and flexibility.

The reference architecture of hyper Ledger, identifies several key layers of components. Consensus, smart contracts, communication protocol, data storage cryptography, id management governance and interconnectivity. This is a major difference from the design of existing public blockchains like Bitcoin and Ethereum, where everything is packed in the same blockchain protocol. Therefore you can imagine that hyper Ledger provides more flexibility for each layer as several options are offered. This means that enterprises can choose the consensus algorithm, the smart contract, programming language, level of encryption and so on, that best fit their business needs.

Some users require a rapid network consensus systems and short block confirmation times before being added to the chain. For others a slower processing time may be acceptable.

In exchange for lower levels of required trust scalability confidentiality compliance workflow complexity and even security requirements differ drastically across industries and uses each of these requirements and many others represent a potentially unique optimization point for the technology.

So the main benefit of the modular is flexibility hyper Ledger develops a range of technological solutions for business applications including distributed Leger's smart contracts code libraries and graphical user interfaces. It also provides entire sample applications. These common building blocks can be reused in many different projects and the component can be modified independently without affecting the rest of the system. Hyper Ledger components can be mixed and matched to create made enterprise value added systems. This framework creates a perfect environment for innovation in the corporate block change space.

Based on this consortium many blockchain networks has been created. Aries, Burrow, Cliper, Cello, Fabric and Sawtooth to name a few. In the next paragraphs I will make a reference to the most know which is Fabric and Sawtooth.

2.6.2.1. Hyperledger Fabric

Hyperledger Fabric was initially proposed by Digital Asset and IBM, as a result of the first hackathon. Fabric's protocol is run by peers who are divided in two categories. In the first category are those nodes who keeps the role of the validator, and they are assigned to run consensus procedures, validate transactions, and maintain the ledger. In the second category belong those nodes who plays the role of connector between the clients and may issue transactions to validators. Nodes of the second category does not execute transactions but they are able to verify them.

Fabric uses Byzantine Fault Tolerance consensus protocol which as we mentioned is executed by the validator nodes. Validator nodes according to Christian Cachin "run a BFT consensus protocol for executing a replicated state machine that accepts three types of transactions as operations:

Deploy transaction: Takes a chain code (representing a smart contract) written in Go as a parameter; the chain code is installed on the peers and ready to be invoked.

Invoke transaction: Invokes a transaction of a particular chain code that has been installed earlier through a deploy transaction; the arguments are specific to the type of transaction; the chaincode executes the transaction, may read and write entries in its state accordingly, and indicates whether it succeeded or failed.

Query transaction: Returns an entry of the state directly from reading the peer's persistent state; this may not ensure linearizability"

Since fabric implementations intent to be used over a permissioned ledger it involves also an authentication and authorization procedure. Every peer who want to enter the network has at first to obtain a certificate from an authority which is part of the membership service. With this certificate the peers can connect to the network where according to the rights will acquire the needed transaction certificates in order to be able to initiate a transaction. Security of transaction authorization is achieved through public-key cryptography while confidentiality secured through in-band encryption.

2.6.2.2. Intel Sawtooth

Sawtooth is a project under the umbrella of hyperledger that initiated by Intel and also delivers a modular platform for distributed enterprise applications. Sawtooth make the blockchain application development very simple as it separates the core system from the application domain. Developers can define what the right rules for their business are and decide on the coding language best fits their needs without no concern of the core system design.

Because Sawtooth is highly modular, advantages enterprises and organizations by granted flexibility in decisions they need to implement. Sawtooth's core design allows applications to choose the transaction rules, permissioning, and consensus algorithms that support their unique business needs.

Sawtooth platform is also uses smart contracts allowing developers to create the logic under which their application will operate. Unlike the other blockchain platforms we saw until now, sawtooth consensus algorithm is proof of elapsed time that is designed to support large networks. Proof of Elapsed Time relies on a Trusted Execution Environment such as Intel Software Guard Extensions.

An application can be a native business logic or a smart contract virtual machine. In fact, both types of applications can co-exist on the same blockchain. Sawtooth allows these design decisions to be made in the transaction-processing layer, which allows multiple types of applications to exist in the same instance of the blockchain network.

Sawtooth in order to help developers prepare their applications faster, has created some example transactions in several programing languages, such as Python, Go, and Java. These transactions work as models for simple functions. Each application defines the custom transaction processors for its unique requirements. A transaction family implements a data model and transaction language for an application. Sawtooth includes example transaction families in several languages, such as Python, Go, and Java. Sawtooth provides several example transaction families to serve as models for low-level functions (such as maintaining chain-wide settings and storing on-chain permissions) and for specific applications such as performance analysis and storing block information.

Another thing that differentiates sawtooth from other platforms is its ability to deal with parallel transactions while the rest of the platforms introduced in this paper require transactions to be executed the one after the other. Sawtooth include an advanced parallel scheduler that splits transactions into parallel flows. When possible, transactions are executed in parallel, while preventing double-spending even with multiple modifications to the same state. According to sawtooth expert, parallel scheduling provides a substantial potential increase in performance over serial execution.

2.6.3. CORDA

Corda is a distributed Ledger technology platform designed in the beginning specifically for financial agreements between regulated financial institutions. The main difference between Corda and the public blockchain like Bitcoin and Ethereum is that Corda is based on consensus only between the parties involved in the deal rather than consensus of the entire network. Corda facilitated businesses to transact directly under strict privacy by using smart contracts. This helped financial institutions to reduce transaction and record keeping costs.

In 2016, R3 launched Corda as an open source blockchain platform with the support of 42 organizations, while in December 2018 its ecosystem reached the 300 members. Distributed applications can be built on Corda using the Java Virtual Machine which facilitates user adoption and interoperability with legacy systems.

Corda transactions are validated by parties taking part to the transaction rather than a broader pool of unrelated validators. Therefore the entire transaction database in Corda is not copied to all network participants. For the same reason corda doesn't have to use any digital currency to reward those who validate the transactions.

In order consensus to be achieved transactions validity and uniqueness must be justified. Validity it has to do with the transaction itself thus if all appropriate signatures are included and the transaction is valid. That is ensured through the smart contract code. Uniqueness is referred to the stakes included in the transaction. The main reason is to be certain that the stakes of the transaction in question are unique and it wasn't used, either all or part of it, in another transaction. The reason for this is to avoid double-spends.

R3 delivers two interoperable and fully compatible distributions of the platform–Corda, a free download based on the code available on GitHub and Corda Enterprise, a commercial version which offers features and services fine-tuned for modern-day businesses. Today, R3 is an enterprise software firm whose customers continue to reap the benefits of the vibrant communities we have built around the Corda platform. Both builders and explorers benefit from two interoperable and fully compatible distributions of the platform.

2.7. Blockchain or Distributed Ledger Technology

As it was already described in the previous chapters, with the advent of Bitcoin and the solution it brought in regard to double spending problem, decentralized technology was able to evolve. Ten years after bitcoin's introduction cryptocurrencies are not treated skeptical anymore and plenty of applications have been created based on this technology. It is a time now where blockchain, Distributed Ledger Technology or DLT and Decentralization are some of the most catching words among technological providers, business forums, academia and even the people. Despite the evolution and dissemination of the particular technology, it looks like there are still plenty of people who mixing up blockchain and DLTs.

Is it really Blockchain and DLTs the same thing? As a matter of fact, Blockchain is a form of Distributed Ledger Technology but it is not the only one. Blockchain was named like this because the transactions are grouped into blocks and then each block is linked to the previous one, thus creating a chain of blocks. Many people believe that the term blockchain was also created by Shatoshi Nakamoto when he introduced Bitcoin and that is why yet many are confused in hearing of blockchain that is linked to cryptocurrencies. Realistically, Shatoshi Nakamoto in his paper never used the term Blockchain. He used many times the terms block or chain but never Blockchain. The closest term to this was chain of blocks. The term was adopted later by users or developers of bitcoin.

Since Distributed Ledger Technology is the one Blockchain derives from, it comes without saying that we need to explain first how this technology work. Fundamentally, Distributed Ledger is a decentralized database which is not allocated in only one server, PC or node but is dealt out to all network participants. Each one of them keep a copy of the ledger and in case data need to be updated, this take place independently to each node. The main philosophy under this implementation is that there is no central authority and each computer or node has the same authority level with all the rest. There are different DLTs but Blockchain is the most famous one. The main difference between DLTs are the consensus model they use which finally is the key element for the main values will be inherited to the network. For example Blockchain's PoW ensures security and transparency but on the other hand lacks scalability.

To make it more conceivable it is better to name a few more DLTs that differentiate with blockchain. Hashgraph is a DLT which unlike blockchain allow multiple transactions taken place in the same timestamp, to be stored in parallel piles. Hashgraph uses virtual voting or gossip consensus techniques which allowing transactions to be verified chronologically, first come first served, thus reducing processing time. Another DLT is the Directed Acyclic Graph or DAG in short which is based on the number of transactions taking place in the network. The more the records, the faster it becomes. One characteristic of DAG nodes is that it can start a transaction but in order to be able to validate it, it has firstly to check up two previous transactions of the ledger. Finally Holochain DLT is coming with a new idea. It doesn't use the same consensus model for all nodes as it is on their discretion which one to use since they run their one independent chain.

2.8. Smart Contracts

As it was already introduced, Ethereum flexible programming language Solididy revealed a whole new perspective to the blockchain technology regarding smart contracts and smart assets. This new way of thinking boosted developers and entrepreneurs to create new innovative ideas which lead to a broader range of opportunities. It has to be noted that not all platforms are using Solidity language to their implementations. For example Hyperledger is using Go and Java while R3 Corda is using Kotlin and Java.

"*A smart contract is a computer code running on top of a blockchain containing a set of rules under which the parties to that smart contract agree to interact with each other. If and when the pre-defined rules are met, the agreement is automatically enforced. The smart contract code facilitates, verifies, and enforces the negotiation or performance of an agreement or transaction. It is the simplest form of decentralized automation*."[7]

As a matter of fact, the so called smart contracts are neither smart nor a real contract from legal point of view. Its smartness depends on the programmer who will write the code

[7] "What is a Smart Contract? Auto enforceable Code - Blockchain," *blockchainhub.net*. [Online]. Available: https://blockchainhub.net/smart-contracts/. [Accessed: 27-Jun-2019].

and the task he needs to make. As it is obvious the “smart contract” could be very simple or contain a lot of bugs and errors since it is based on human logic and actions. Similarly, is not a legal contract as there aren’t any legal effects if it isn’t executed.

Based on the Ethereum paper, the applications that could be built on top of blockchain infrastructure can be separated in three main categories. .

1) In the first category are those applications which are direct linked to financial products like financial derivatives, escrow accounts, trade settlement, crowdfunding, insurance and other. Those are typically more complex financial projects than money transfer and the need of smart contracts is essential for their development.

2) The second major category includes those applications which might involve financial elements but they also contain substantial non-monetary components. Such applications can be used to any decentralized peer to peer marketplace for products or services like gaming or prediction markets. One such application based on Ethereum is Funfair. FunFair isn’t a casino operator itself; instead it licenses its technology and games to casino operators. It provides a turnkey online casino technology that can be used as a white label solution by anyone anywhere to create an online casino with the help of block chain and smart contracts.

3) The third category is comprised by applications that can benefit from blockchain architecture and smart contracts but are further away from financial services. In this category we will find applications for supply chain management, digital voting and decentralized governance.

The applications encompassed in the first two categories compose the so called digital economy, while the third category applications are those creating a new digital society. In the next chapters it will be presented cases studies where blockchain technology leads us to the digital economy and the digital society.

In the following table you can see the main features of the most famous platforms.

Characteristics	1st Generation	2nd & 3rd Generation				
	BITCOIN	**ETHEREUM**		**CORDA**	**HYPERLEDGER**	
			Quorum		Fabric	Sawtooth
Platform	Bitcoin software	Ethereum software	Based on Ethereum with extra features	Specialized for Financial Industry	modular	modular
Governed	Miners, Developers, Users	Ethereum Developers	Quorum	R3 corporation	IBM	Intel
Permission	Public	Public	Private	Private	Hybrid	Hybrid
Consensus	Power of Work	Pow, PoS, Casper	BFT, Raft	BFT, Raft	BFT	PoET
Smart contracts	Yes with limited functionalities	Yes	Yes	Yes	Yes	Yes
Programming Language	Open source (Bitcoin core etc)	Solidity	Solidity	Kotlin, Java	Java, Go, Node.js	Python, Go, Java
Token	bitcoin	Yes (Ether) & No	No	No	Yes & No	Yes & No

3. METHODOLOGY

In this chapter it will be presented the methodical approach of the study regarding evolution of blockchain technology from its birth to current situation. Our study was based on documentary analysis in order to collect all the appropriate data that would help us understand how the technology works, which are the stages it went through and the sectors finally disrupted. Documentary analysis could be defined as "a systematic procedure for reviewing or evaluating documents-both printed and electronic (computer based and internet-transmitted) material[8].

In the first stage a literature review was conducted in the bibliographic databases of Google Scholar and IEEE Xplore using the words "Blockchain", "Distributed Ledger Technology", and "Bitcoin". Analyzing the results, brought to light new terms like "Ethereum" "Smart Contracts", "hash function" etc which were also used for a new bibliographic search in the same databases. It is obvious from the google trend analysis that the term of Blockchain the last five years have seen an immense increase and the same goes for similar terms like decentralized, bitcoin, DLTs and Ethereum.

Our aim in this first stage was to collect the most relevant information regarding the Blockchain technology operation and its key features, as the reader would not have to go through his own research in order to understand the technology before reading our paper. Since the volume of the available literature is too big, we focused on the first 20 results which also ordered hierarchically from the most recent to the oldest one. Finally those who contained the most relevant and replete information composed the base of our two first chapters.

The second stage of our study included literature review of existing use cases and for that reason the terms "blockchain use cases" and "blockchain projects" were used. This time the research included except the aforementioned databases and commercial sources. The

[8] G. A. Bowen, "Document Analysis as a Qualitative Research Method," Qual. Res. J., vol. 9, no. 2, pp. 27–40, 2009.

results of the later revealed organizations specialized in implementation of distributed ledger technology as well as specialized forums and expert online communities which was used for extra literature review and monitoring developments. Such communities were the Hellenic Blockchain Hub, European Union Blockchain Observatory and Forum, hyperledger.org and ibm.com/blockchain.

As happened in the first stage, the literature and relevant information was huge so we needed to categorize each case on groups so it would be easier to examine similar cases together. The initial framework was based on PWC's global blockchain survey[9] which was conducted in 2018 and among its results it was also presented the leading industries on blockchain. Having that as reference, our research on use cases was combined with terms as "financial services", "supply chain management", "health care" "government" and so on. The use cases tracked down were categorized in each industry.

In regard to the use cases it was discovered through my research, also the involved companies' sites where visited in order to discover more details for the project. Some of those use cases are introduced in the paper as to strengthen the theoretical approach of the specific chapter. The final conclusions are based on all the discovered use cases, even though on some of them I wasn't able to find sufficient data. In the Appendix at the end of the paper it is written down all those cases that the information published were enough to give us the opportunity to understand its key points.

Having in mind the results of the research first stage review and the classification of blockchain, derived from its evolvement in 1.0, 2.0 and 3.0, we took the initiative to classify also the projects based on those categories. Since our research was focused on the way business and governments could be leveraged by the use of blockchain, there were no use cases in regard to cryptocurrencies and that is why blockchain 1.0 it doesn't included in our categorization. Following the above, and based on the way projects of each industry were implemented or designed, we classified each industry in two major groups, digital economy and digital society which represent blockchain 2.0 and 3.0 respectively.

[9] PWC, "Blockchain is here. What's your next move?", 2018 [Online]. Available: https://www.pwc.com/gx/en/issues/blockchain/blockchain-in-business.html [Accessed: 27-Jun-2019].

Taking into account that Blockchain technology it isn't the only one driving us to the fourth industrial revolution, in the seventh chapter it is given an account of the correlation between blockchain, Artificial Intelligence and Internet of Things. The reference is grounded on how some of the features of each technology can cover the disadvantages of the other, so that blockchain can act as a mediator which will boost the mass adoption of the other two technologies.

The final stage of our research aimed at identifying the legal framework of blockchain implementation. Academic literature in this context is scarce and many of our information retrieved from commercial sources. A lot of information was retrieved through the reports published by the European Union Blockchain Observatory and Forum which are based on forum's working groups and inputs from participants in different workshops organized by the Forum across Europe.

METHODOLOGY ANALYSIS				
STAGES	**SOURCES**	**SEARCH TERMS**		**RESULTS WEIGHT**
		Main	**In conjunction with**	
1st	Google Scholar IEEE Xplore Commercial Sources Google Trends	Blockchain Distributed Ledger Technology Bitcoin Ethereum	Decentralization, Security, hash function, platforms, Consensus Mechanisms Peer to peer, Smart contracts	i) Source origin ii) Relevance and completeness iii) First 20 results iv) Oldness
2nd	Google Scholar IEEE Xplore Commercial Sources Blockchain Companies site Blockchain official forums Consultancy firms	Blockchain and Distributed Ledger i) projects ii) use cases iii) implementations	Economy, Financial, insurance, gaming, Government, health care, banking, trading, supply chain management, media	Relevance and completeness
3rd	European Parliament European Union Blockchain Observatory and Forum Commercial Sources	Blockchain Distributed Ledger Technology	Legal issues, regulations, laws, rules, framework	i) Source origin ii) Relevance and completeness

4. DIGITAL ECONOMY

Since the first time bitcoin was brought to light, it was obvious that the first sector would be effected was banking. In the beginning the whole project looked as something that would interest only a few but when it was widespread gave people a viable alternative. Bank executives understood that they needed to follow and a good example are the words of JP Morgan CEO Jamie Dimon, mentioned in his letter to the bank's shareholders back in 2015. *"There are hundreds of startups with a lot of brains and money working on various alternatives to traditional banking,"*[10]. So let's see some of the existing banking services that is going to be impacted by blockchain solutions.

4.1. International Payments

Billions of dollars are paid in banking fees each day. In a report compiled recently by KPMG for central banks Bank of Canada, Bank of England, Monetary Authority of Singapore and commercial banks HSBC, TD Bank, OCBC Bank and UOB it was referred that the overall value of cross-border payments is expected to rise by 5.5 per cent per year from US$22 trillion in 2016 to US$30 trillion in 2022 across both retail and corporate payments. Some of these fees are clearly shown to customers and are for services rendered while others are less obvious and arise when banks carry out operations related to foreign exchange for example.

Bank transfers as operate today are time consuming. In order money to be transferred from a bank based in Greece to another bank based in a country of European Union needs at least two working days. That happens because plenty intermediate steps must take place, such

[10] A. Shontell, "Jamie Dimon shareholder letter and silicon valley," *Business Insider*, 2015. [Online]. Available: https://www.businessinsider.com/jamie-dimon-shareholder-letter-and-silicon-valley-2015-4. [Accessed: 27-Jun-2019].

as working with correspondent banks and of course we have also to count the bureaucracy and paperwork needed for justification and control. Take into account also the exchange rate losses, counterparty risks and people working hours, making these transactions complicated, expensive and time consuming. This procedure is by far more difficult when one of the banks have no representation in the correspondence country.

Today many people use other financial institutions like Western Union, even though is more expensive, because saves them time. With the use of blockchain technology this kind of service would take from minutes to few hours as no intermediaries needed.

Banks all over the world started to examine the new possibilities of blockchain few years ago. There were plenty of talks and initiatives but what we have to notice is that in the beginning of May 2019 the Monetary Authority of Singapore (MAS) sent $105 Singapore dollars to the Bank of Canada (BoC) in a proof-of-concept project. It looks like that this consortium is closer to the solution of cross-border payments and settlements.

4.2. Investment Banking

For business world selling and buying shares and stocks is everydayness. Anyone familiar to this procedure will recognize the many different entities are involved in it. Except buyer and seller you need also a broker and the stock exchange itself. Apart from the time needed for the transaction to take place, work need to be done also afterwards in order the list of shareholders to be updated. Take into consideration the number of shares trading daily in a stock exchange. What we are facing again are the middlemen, a lot of paper work and bureaucracy.

Once again the key feature blockchain is offering is its decentralized nature which gives the opportunity all the unnecessary middle actions to be removed. Of course this will not be the only benefit. Take for example that the use of blockchain technology will reduce the storage space needed for information redundancy. Plenty of time and money will be saved. Blockchain technology could help in many areas of investment banking. Trade surveillance, data sharing

for customers in order to combat Anti-money laundering, regulatory reporting and know your customer. The ability to settle currency and fixed income trades almost simultaneously create a significant opportunity for banks to drive efficiency, improve regulatory control and eliminate unnecessary intermediaries.

Interestingly some of the major investment banks worldwide have been exploring opening cryptocurrency trading desks. The biggest project of all is the one under the umbrella of Fnality International. Fnality, backed by a consortium of financial institutions including many of the Globally Systemically Important Banks (GSIBs) who sponsored the "USC Project". UBS, Barclays PLC, Nasdaq Inc., Credit Suisse Group AG, Bank of New York Mellon Corp. and other banks in the U.S., Europe and Japan, have created this company to control development of the token, called the utility settlement coin, or USC. The USC token would function both as a payment device and messenger that carries all the information required to complete a trade, potentially cutting down on a transaction's time and cost.

4.3. Trade Finance

Another sector blockchain will disrupt for sure is trade finance and escrow services. This example was already referred before but I would like to put some more details on it. Most of the trading parties today are making business all over the world without in fact trusting each other. Banks are taking advantage of this and present themselves as a trusted third party that could guarantee to both market participants the trade is safe to take place, either by providing letters of credit or with escrow services.

This procedure is very time consuming and of course expensive as the banks are paid for their services. Banks before act as middleman will have to check the financial condition of the participants in order the risk hand over to them. In autumn 2017 in an attend to minimize risk and speed up the trading process, Eurobank cooperated with other foreign banks in order each one of them create a list of enterprises which potentially could do business together. The

new idea to all this was the fact that the listed enterprises would have already been control and the bank could guarantee any trading action up to specific amount of money.

Trade finance thought it's not only risk and money. In most cases a single deal involves a buyer, a seller; buyer's bank, seller's bank, a transportation company and local authorities. The entire process requires plenty of paperwork and isn't automated because all participants have their own separate systems. The process taking weeks in some cases and is expensive for companies given that they have to pay man hours while they cannot use any of the deal proceeds until it is completed.

Imagine now how platforms based on smart contracts will transform this line of business. The two parties in a business transaction will be able to design a mechanism that transfers the goods and money automatically. The conditions according to which the deal will take place will be programmed into a smart contract and both parties can be certain that these are immutable and will be executed automatically.

Such an innovation is already on its way and is called Batavia. Batavia is a platform built on IBM blockchain platform and involves a partnership between IBM and five banks (UBS, Bank of Montreal (BMO), CaixaBank, Commerzbank and Erste Group). Its aim is to create a cross border network which will be open to organizations around the world. Companies will be able to use the platform to enter into agreements with each other using standard forms.

What is even more important is that the degree of transparency and trust in the system will increase due to its secure and immutable ledger. All parties involved will be able to track the progress and whereabouts of the goods exchanged. Another key feature is that money can be paid to different participants in the trade at different stages as goods move along the supply chain. For example a company will be able to pay its supplier once goods are in the hands of the logistics firm then the logistics firm will be paid once the shipment arrives at its destination.

The first live pilot transactions were successfully completed. Cars were traded from Germany to Spain and raw textiles for furniture production were traded from Austria to Spain. Participants managed with the use of Batavia to create a more transparent process as all

the related documents and payments are obtainable from anyone involved in the trade, since it is digitalized and electronically maintained.

This is a great example of a platform that has been constructed using block technology and increased efficiency and effectiveness for all parties involved, thereby creating value and stimulating economic growth. Now that the minimum of the product has been developed and the initial pilot transactions worked perfect, the consortium plans to build a production ready solution, targeting in transforming clients experience through transparency and trust to each and every step of the trade process.

4.4. On line Gaming

Nowadays, online multiplayer games are very famous and all players are vying to get ahead of their opponent by creating a more competitive digital character (avatar). To do so, some extra assets and experience is needed. Digital assets are purchasable either with real money or with tokens (digital money) the player gains while he is playing while experience is most of the times linked with play time and fulfilled tasks within the game. Both virtual items and avatar experience are of significant value as first of all offer leverage over your opponent and secondly those can be expensive and time consuming to acquire.

There were incidents among players that someone was hacking the system in order to steal other players' assets or creating new digital assets for him. The biggest problem online gamers are facing with digital assets is indeed the difficulty to ratify their ownership. Another problem is that since they started a game in one platform is very difficult to move to another because they cannot take with them the virtual assets they have already gain.

By design, blockchain is a decentralized Peer to Peer technology and inevitable industries like gaming which are mainly based in interaction with a lot of people simultaneously would be influenced of it. An additional element making blockchain easier to be adopted by gamers is the fact that they are already familiar with digital coin transactions.

Peer-to-peer structure of blockchain can be utilized to offer real-time cheat prevention while through its decentralized nature can control all gamers' activities and offer transparency in virtual assets ownership. Gamers will be able to use the same account over different platforms thus carrying with them all the previous experience and assets their avatar had. This will allow players to be more flexible and face better entertainment experiences.

WAX is a worldwide asset exchange for video games virtual goods. The platform was built over blockchain technology, meaning fully decentralized and open to anyone who want to create his virtual shop without the need to invest any money on payments processing, infrastructure and security. Users collecting tokens (WAX Tokens) that allow virtual gaming assets not just being used for the gaming itself but they can easily be tokenized and exchanged for cryptocurrency. The whole mechanism allowing trusted trading is written over a smart contract. No more wasted time and money for players. As it was mentioned, players of an online game were purchasing different digital assets in order to move to the next level. The time the player decided to leave the game for another one, all purchased items were lost. Now through WAX platform can sell its products to new players on game A and use the money to purchase items in game B.

4.5. Insurance

Another business sector where many stakeholders are involved for the completion of an act is insurance. Insurance is a complex market with different implementations. General in an insurance contract, except the person or company acting as receivers of the service and the insurance company, there are also other intermediaries like a doctor, car mechanic, another insurance company, experts, banks, state officials and many others. With so many participants in the chain we are inevitably driven to a very costly and time consuming insurance claim process. What is more, insurance companies need time to conduct all necessary controls to avoid fraud and fake insurance claims.

With the development of smart contracts in blockchain, providing a high degree of automation, insurance companies found an ally to address the aforementioned problems.

Strengthens of blockchain technology will help to reduce insurance costs; the claim procedure will be faster and more transparent. This will increase insurance companies' reliability and will offer a better customer experience. Every single detail will be written down to a smart contract and when a triggering event occurs, immediately the claiming process will start based on pre-agreed conditions. Most important; the whole procedure would be auditable from all stakeholders.

Such projects have already started. One good example is insurance company Alianz. In 2016 they demonstrated in cooperation with Nephila Capital Limited a beta version of a platform simplifying and accelerating the settlement of catastrophic swaps and bonds. According to the company the platform helps holders of such financial instruments to receive or make a payoff faster and easier. As it was mentioned above, in the case of a triggering event a shorter waiting time for both parties will be needed, which results less uncertainty for people buying these products, and less verification errors.

Allianz didn't stop only to this implementation. In November 2017 announced that a blockchain prototype for captive insurance market had successfully been implemented. For this prototype Allianz cooperated with EY, Ginetta and Citi Treasury and Trade Solutions. Captive insurance programs are very complex as they are created by global organizations which instead of buying insurance products they are creating their own. These organizations collect premiums (bonds or options) from the companies' operate under their group and then paying out them globally as those premiums increase. Blockchain prototype helped them to automatically connect all stakeholders which could manage the data entering the system, all entities transactions and any updates in real time. The prototype was built on Hyperleger Fabric 1.0 and focused on three processes flows of captive insurance cycle. These are annual policy renewal, premium payments and claims submission and settlements.

5. DIGITAL SOCIETY

Undoubtedly, our era is flooded by digitized data which have profoundly affected every angle of our lives. You can see it in the way we work, we learn, we participate in economy and politics and how we choose to socialize through social media. Digitalization promises tremendous benefits for better health, more efficient mobility, efficient energy use, and flourishing companies.

Governments, businesses and the public would benefit the most from digital innovation as it provides them with a great opportunity to transform the way they are related. Digital technology come up with new tools and ideas that are changing institutional relationships and the way society operates, empowering individuals, and their ability to both participate and contribute to decision-making. In the previous chapters it was introduced how economy is transforming really fast from a centralized to decentralized one, with the help of blockchain technology.

In the interests of democracy and transparency, it is of the utmost importance that governments will allow an easy access to their data. This information which is created and guarded by the state, constitutes a vital resource for economic and social innovation in digital society. On the other side data, especially the sensitive personal ones, need to be securely accessed and their integrity and immutability must be ensured. These are some of the key features of blockchain technology and we have to take these benefits under consideration when we are going to apply new applications.

Building smarter cities, improving access to eGovernment and eHealth services, establish Decentralized Autonomous Organizations will enable a truly digital society. For example European Commission is taking concrete actions for the development of cross-border digital public services and ensures the use of digital tools and systems to provide better a modern eGovernment to citizens and businesses.

To highlight the importance European Union is paying on blockchain technology we need to notice that on the council conclusions of 19th November 2017 blockchain and artificial intelligence were named as key emerging trends. Following that, on February 1st 2018 European Commission launched the EU Blockchain Observatory and Forum. Its objectives are to map key initiatives, monitor developments and inspire common actions

5.1. Decentralized Autonomous Organizations

Traditional organizations or companies are governed either by one person, who usually is the owner, or by a group of people known as the Board of Directors. Even though there are different administration models, the basic element to all are based in a hierarchical centralized system. Company's directors are the ones drawing the strategy it must be followed and determines company's targets. The remaining members have to follow the decision and take all the necessary actions to fulfil the goals.

Each organization or company operate under some rules which are imposed by shareholder agreements or company's bylaws and framed by state laws. Fundamentally, organizations are able to operate only under humans' supervision and the basic problems that have to confront are originated from the human nature. The first is that people are not always follow the rules and the second one is that two people or a group of them would argue on the different perspectives each one has for a certain law.

Blockchain evolution and the use of smart contracts brought to the forefront a very innovative idea. Could be potentially an organization managed automatically without any human management involvement? This is how the concept of decentralized autonomous organizations were born. Similar to digital currency, Decentralized Autonomous Organizations (DAO) or Decentralized Autonomous Corporations (DAC) are consider as autonomous entities that operate on the block chain in a completely transparent and publicly managed way without any central control.

The relationships among investors, owners, employers and other stakeholders as well as the assets and resources of such enterprises are going to be managed by smart contracts on the block chain rather than by legal contracts and organizational bylaws. All participants thus the nodes of the organization, will have the same rights to make decisions based on the algorithm of the smart contract. It means that no one has special privileges in operating the organization. A series of contracts would execute the business plan in order to accomplish its mission based on set of logical rules. They can buy resources or services, hire people or machines for jobs, pay suppliers, partners and employees, run marketing activities, logistics distribution sales and so on in order to create value for their owners.

Autonomy is the major feature of Decentralized Autonomous Organizations. A DAO requires an automated program to ensure that the decisions can be executed without any manual intervention. Human intervention may be needed only to maintain and upgrade the smart algorithms. When an event or a set of events in the contract is triggered, smart contract will be executed automatically by the decentralized system. Procedures within enterprises will run faster which be a big advantage especially for global organizations. Decisions will be based on all available data needed to complete a task. On the other hand we don't know what will happen if an unexpected event occur that haven't been foreseen. Maybe this kind of problems will be solved when artificial intelligence will be implemented in the form of machine learning.

One of the first implementations regarding autonomous organizations started on May 2016. The project was called (The DAO) and it was a venture capital fund for cryptocurrencies. It was built on a smart contract on top of Ethereum network by few members of Ethereum community and it was developed on open source by the Slock IT team. In a small period of time they managed to collect 150 million dollars which put it in the first place of crowdfunding organization ever.

The smart contract was quite complex, consisted of many features and allowed companies to make proposals for funding. In the beginning the proposal was whitelisted and in order to be accepted it was needed 20% of the network curators to vote in favor for this transaction. The team of curators, who most of them were well known members of the Ethereum community that had the right to approve the proposals were put in place in order to

avoid spam proposals and so as to have some human oversight in the automated process. Smart contract included also the ability of an investor to leave the organization no matter the reason.

The project was launched smoothly but in a small period of time some security issues came up which didn't addressed immediately. This resulted to a hack incident in June 2016 were 70 million dollars were drained in the first few hours. The attack was possible because of a bug in the part of the code used by investors when they wanted to leave the organization. It is crucial to mention that he problem wasn't in the Ethereum blockchain but in the smart contract which was built on it. Finally the hacker stopped the attack but nobody understood why as he could continue to do so. The DAO team took over control and presented some alternatives to deal with the exploit.

To summarize, such implementations looks promising and represents a technological innovation on organizations management which will make them more efficient and transparent. Yet many things need to be tested and examine thoroughly. So many further steps are need to be taken and probably synergies with other technologies like artificial intelligence in order to reach in massive adoption. Another big issue that need to be addressed is the law and principles under

5.2. E- Governance

eGovernment includes the services provided by public authorities with the use of information and communication technologies (ICTs) in order to improve government efficiency and increase democratic participation. To accomplish this purposes governments focus in the reduction of the electronic information management and communications costs and the reorganization of government agencies. Public authorities, even more importantly, should reduce administrative burdens on citizens and businesses by making their interactions with public authorities faster, more convenient and less costly, thereby spurring competitiveness and economic growth.

As every other sector e-Government went through many stages of evolution. We can distinguish three stages. Government 1.0 which focused on the exploitation of ICT for improving internal efficiency and for providing electronic transaction services to citizens and firms through various electronic channels. Government 2.0 which focused on the use of Internet and social media for promoting transparency, citizens' participation and collaboration, and in general the concept of 'open participative government' and Government 3.0 which is associated with the use of disruptive ICTs such as big data, blockchain technologies and artificial intelligence technologies in combination with established ICTs such as distributed technologies for data storage and service delivery and the wisdom of crowd (crowd-sourcing and co-creation) towards data- driven and evidence-based decision and policy making.

Nowadays, most countries in the world have been providing e-services, in which the governmental public services are implemented by information and communication technologies, to serve its citizens better. European Action Plan for e-Government is guided by the following vision: "*By 2020, public administrations and public institutions in the European Union should be open, efficient and inclusive, providing borderless, personalized, user-friendly, end-to-end digital public services to all citizens and businesses in the EU. Innovative approaches are used to design and deliver better services in line with the needs and demands of citizens and businesses. Public administrations use the opportunities offered by the new digital environment to facilitate their interactions with stakeholders and with each other.*"[11]

Following the above, it is obvious that new technologies are placed in the center of e-services innovation. Blockchain as one of the promising new technologies will provide plenty of possibilities for innovative implementations which will change the way people and public authorities interact. Core values of Distributed Ledger Technology will improve the quality of existing services while in parallel new ideas will be born.

In the heart of blockchain technology is transparency, a feature that governments should use to maximize their integrity. Although data are circulated openly in the blockchain and could be publicly visible, yet cannot be modified or deleted. People would have the ability to access those data easily while it will benefit different public services to share information

[11] A. . Fallis, "EU eGovernment Action Plan 2016-2020," *Eur. Comm.*, no. 2016, 2016.

thus improving their interoperability. Another great feature of blockchain is its consensus mechanism which provides people with a great tool, to decide who will or won't have access to his data.

Public services until today was provided by centralized systems which heavily rely on humans to control them and made them vulnerable to outside attacks. The blockchain-system works in a fully decentralized way and is immune to both outside and inside attacks. At the same time, operations of such system is only controlled by pre-defined rules, thus the uncertainty and errors caused by human processes are greatly reduced. The advantages of this goes beyond infrastructure costs. Gradually citizens will have less interaction with public servants, reducing corruption incidents. Governments leveraging the emerging decentralized technology of blockchain will furnish their electronic services with security, immutability, reliability, and transparency features.

Exemplified by private sector, governments have already started to adopt blockchain in their operations. In a research conducted by Deloitte in conjunction with the Fletcher School at Tufts University, in March 2017 117 public blockchain initiatives were counted in 26 countries globally. In March 218 the Organization for Economic Co-operation and Development (OECD) based on data collected by The Illinois Blockchain Initiative found 202 public blockchain initiatives in 45 countries. In the above data are included many of the announced areas in which public sector leaders are considering using blockchain. Both researches show that the most interesting projects for governments are identity management, voting and asset registry. In the next paragraphs those projects will be examined

5.2.1. Identity management

This use case will help government entities to manage and maintain digital identities of individuals to support the processing various government applications. When we are talking about digital identity we don't have to see it as the identification cards we are using today. It would be a record online something like an account where all personal data will be stored. Id

number, social security number, driving license, when and where we were born, health records and so many other things.

All these records will be kept safely in blockchain and tamper free. This will increase trust between people to any form of their financial and social life. There would be no fear for fraud incidents between people and public authorities, banks or companies as both counterparties would be sure about the other entity. People will have a full control of their data and they will decide who will see what and when. Additional this will help the different companies or organizations to be more efficient, reduce their costs, minimize risk of losing personal data and finally increase compliance. This will be resulted as organizations and companies won't have to store on their one all these data as it will always be available.

A great example is the Estonian government who is collaborating with Bitnation, the world's first operational Decentralized voluntary nation, to offer public notary services to Estonian e-Residents. Estonian e-Residents has digital IDs that are issued by the Estonian State, and these digital IDs can be used to notarize official documents such as birth certificates, marriage arrangements, business contracts, land titles, and other from anywhere in the world. It offers also the ability to create a new company and file your tax declaration.

Another aria it would be useful is the refugee crisis. Something similar it is implemented in Finland in order to give them access in banking system. The problem with refugees is that most of them don't have identification papers with them and for those they have you cannot be sure if it is valid or not. Instead of issuing paper identification a blockchain system should be set in entry points. There a digital id will be created with the use of biometric features. This will make their lives easier as it will increase their credibility and help them find jobs and have access to financial institutions.

5.2.2. Voting

Key element for a successful voting system is integrity and transparency. This by design makes the implementation quite complex. First of all the voters should be anonymous, the votes should be remained as is but the whole procedure must be auditable in order for voters

to check that their votes was taken into account and the government that nobody voted twice or somebody voted using an intermediary.

Blockchain can offer all the above features. As a matter of fact voting looks pretty much in operation with cryptocurrencies. Instead of sending bitcoins users will send their votes. Once a token is sent you cannot use it again, the transaction cannot be changed by anyone and everyone can see the transaction and starting point to the digital address it ended. The user though remains anonymous. This is exactly what we need for elections. Such a deployment will create high integrity towards the government as it will minimize corruption. An addition benefit is its ability to vote from anywhere with the maximum of security, something to my opinion will help to reduce also the absent voters.

On March 7 2018 , elections in Sierra Leone marked a global landmark as the world's first ever blockchain-powered presidential elections. Votes cast were manually recorded by Agora, a Swiss foundation offering digital voting solutions, using a permissioned blockchain.

5.2.3. Value registry

Value Registry it is a subject I was already referred to in the blockchain 2.0 chapter. It was the main idea after the implementation of smart contracts. Any asset could be digitalized and distributed over the internet. The establishment of a value registry will overcome the problems of documents validation. You can imagine this as business registry is working today. You don't need to ask always for documentation. The companies publish what they are obliged to do. Interesting parties in order to check the validity of the data or the document can visit the business registry online page and see if it is valid or not.

As it was explained blockchain doesn't need any intermediaries or central authorities to rely on. Value registry could include land registry and car registry. Buying and selling of these values through blockchain would increase transparency, and minimize the costs not related with the asset itself but other expenses for lawyers and the notary. People wouldn't have to sign new contracts every time they want to transfer their property and now backround

checks would be needed before the buy as both land and cars assets would be followed by a full historical record.

Such solutions are offered by a blockchain company called Falcon. Falcon mission is, as they presented, to provide an easy way for enterprises to add data integrity and trust to existing processes using the power of blockchain. Harmony Integrate supplies a REST API to chronologically link enterprise data, documents, and transactions on the Factom blockchain for immutable record systems. It enables enterprise businesses to build data integrity and trust capabilities into existing apps to support compliance, auditing, and collaboration initiatives. One of Factom's use cases in government was the land registry initiative of Honduras country back in 2015.

5.3. Supply Chain Management

Supply chain management is a crucial part in all kind of businesses. Businesses and organizations, invest a lot of money in planning of a supply chain which will help them to eliminate the risk of products or services scarcity. As we all understand the most critical link in the supply chain is suppliers. Suppliers are selected on the basis of their ability to provide the required materials in the appropriate time, in the best quality, the right quantity and at the lowest price. In this way they help their clients to achieve their goals and their consolidation in the market. Similarly, they should be able to quickly respond to new customer demands or to modify existing ones.

It was written quite a few times in this paper that blockchain technology can accord many industries with improvements and efficiencies. The first coming to our minds when we are talking about buyers and suppliers are the middlemen. By eradicating them, blockchain is a good tool to do so, products will be cheaper. Another part where supply chain will be benefit is the planning. Both the buyer and the seller would know products stocks and availability respectively. Global organizations nowadays in order to succeed something like that must invest a lot of money in information technology equipment and force their suppliers to use the

same software with them. Imagine how difficult that would be, all suppliers to implement different system for each of their clients. On the other hand block chain network can be accessed by any operating system.

The biggest supply chain globally is related with food industry and since this has a great impact in our everydayness, I believe there is no better use case to examine than this. Today many of the food industry leaders have seen the effect Distributed Ledger Technology could bring and some have already introduced their own solutions while others took the initiative to embody such solutions in their business models.

Far more than reducing middlemen, food industry companies identified that one big advantage for their sector would be transparency and control from the first time of production to the last stage of consumption. As it was mention in the first chapters, data once entered in the blockchain are immutable and always accessible from all nodes. This could reduce time delays, human mistakes and fraud. What is more, consumers will be also benefit. They will be able to check the product origin, its producer, conditions during production, the date it was stored, for how long, when it was shipped to the next one in the chain, what was the conditions during that transportation until the time will end up to consumers baskets in supermarkets.

Someone could argue that industries can do the same thing by implementing RFID to the products to track the movement of the products and combine it with IOT devices to record all temperature data. The missing piece to this implementation that blockchain will cover is the fact that all stakeholders can monitor each other transactions. This will develop trust between the participants and will help eliminate the chance for fraud and inaccuracies.

Golden State Foods is one example for blockchain implementation in food industry. Golden State Foods is one of the largest diversified suppliers to the foodservice industry, servicing approximately 120,000 restaurants in more than 40 countries from its 40+ locations on five continents. *"Last year GSF partnered with IBM to pilot a solution that combines radio-frequency identification (RFID) to automatically track fresh beef's movement, IoT devices to*

monitor its temperature, and blockchain to orchestrate the business rules between parties in the supply chain.[12]"

The whole project based on IBM blockchain technology and its special implementation for food supply called food trust. Food Trust is connecting participants across the food supply through a permissioned, permanent and shared record of food which can be monitored securely. Food Trust implementation is targeting to increase food safety and freshness, unlock supply chain efficiencies and enhance brand's reputation through transparency for both consumers and regulators. It can also be used to monitor waste and emissions in every point in the supply chain. This has serious implications for understanding and controlling the real environmental impact of products.

Another example is TradeLens, a Maersk and IBM solution formerly known as Global Trade Digitization (GTD) which is a trade platform for containerized shipping and connecting the entire supply chain ecosystem. The TradeLens ecosystems is comprised of over 100 diverse organizations including carriers, ports, terminal operators, 3PLs, and freight forwarders. It is also comprised of shippers from around the world. Together, participants publish and subscribe to data under a shipper determined digital permissioning model.

The TradeLens platform integrates trade data from industry partners onto a common, secure business network, and provide real-time, secure access to end-to-end supply chain information to all actors involved in a global shipping transaction. It also allows you to manage the documents involved with a consignment. Submitted and generate events for your documents. This adds to the complete view of activities involved with your consignment or transport equipment. The TradeLens document functions could be used as part of the process of submitting filings for the import and export of goods by enabling end users to securely submit, stamp, and approve documents.

[12] Golden State Foods, "GSF Partners with IBM to Go the Extra Mile with Blockchain -," *Golden State Foods*. [Online]. Available: https://goldenstatefoods.com/news/gsf-partners-ibm-go-extra-mile-blockchain/. [Accessed: 27-Jun-2019].

5.4. Health Care

In the previous chapter we examined the benefits of blockchain in supply chain management and it goes without saying that the same can be applied in healthcare supply chain. We talked before on the importance of products freshness, well imagine how vital would be for a doctor performing a surgery to know that the blood he is going to use kept under the right conditions from the very beginning. Indeed some initiatives have already been taken from companies like MediLedger towards this direction, but espousing blockchain technology in health care goes beyond its supply chain management.

The idea of using a distributed ledger technology in healthcare is interwoven to the immutability it offers to the data is written and circulated under its infrastructure. Medical records integrity is an essential use case for blockchain. For example one hospital records a person's blood type as A+ type. After a couple of years another medical institution tries to record the person's blood type as B+. Because of consensus algorithm used in blockchain the second record will not be accepted if the patient will not agree. Practically if medical records were digitized the first time there wouldn't be any need to record it the second time.

Another big issue for healthcare industry is the fact that all kind of data belong to the category of sensitive personal data thus making difficult to use because of consensus needed and a lot of security measures need to be taken before any action. Blockchain technology advantage users with the ability to use pseudo-anonymous accounts. Practically it means that patients will not publish their names but a digital address. Thereinafter health records will be encoded to digital assets and then entering the blockchain network. Each people will have his own personal account with all his medical records stored in it, which then according to his needs could share it with doctors, pharmacies, insurance companies and other entities through smart contracts or private keys.

It's been a year now that in European Union the General Data Protection Regulation has been imposed. The general idea of the act is to ensure respect for citizens' rights, their privacy and consent. All these characteristics belong in the core values of distributed ledger

technology. Blockchain though can offer an additional security feature. Original medical records could be stored outside public blockchain and what would be distributed is their hash.

As a consequence to what has already been mentioned, a Health registry similarly to business registry it would benefit health industry. The patient would be able to issue Insurance certificate, being informed for the test results without visiting again the hospital, prescriptions would be transferred directly from doctors to pharmacists and keeping the persons medical status always updated. First coming to everyone's mind is how time efficient this service would be for every stakeholder. The biggest advantage though would be individual's health history. All his exams and treatments would be recorded. All the medicines he had taken, all the treatments he had received, information associated with doctor's visits, illnesses, operations and more could be accurately captured.

Data captured on blockchain can be shared in real time. Every event or transaction is time-stamped and becomes part of a long chain, or permanent record, that can't be tampered with after the fact. Individuals would have the full control of their data and decide who would have access to their records. Doctors and medical institutions with the patient consent would have immediately in front of their eyes a lifetime history of the patient's health records which will help them decide faster and based on a more holistic view which treatment would feet the best. Today, a small percentage of medical institutions systematically integrates patient-reported data into their care routines or taking them into account during decision-making.

Another benefit is that the treatment can be carried out online by face-to-face consultation with a doctor. Especially for peoples leaving in villages or small islands that would be of a great help. The state would be able to monitor efficiently the social security services and tackle any kind of fraud. Specialized services based on specialist treatments are particularly significant. Today patient consent is recorded separately for every visit and for every doctor or institution. Interoperable blockchains spanning institutions could be a platform for aggregating trusted data.

As of today, medical researchers had access only to a small amount of data in order to conduct their studies. With patient consent, anonymized and aggregated data could be made available to researchers and other organizations that benefit from access to total population

health data. Medical data can be analyzed but kept private. In healthcare, just 10 percent of data covers clinical factors. A massive 60 percent is made up of exogenous factors or things that happen outside the clinical setting, such as nutrition and home monitoring. "*The value of sharable and secure electronic health records is easily apparent. According to the Premier healthcare alliance, sharing data across organizations could save hospitals USD 93 billion over five years in the U.S. alone. Seventy-two percent of Trailblazers expect big impact from blockchain-enabled medical records*[13]*"*.

On the nearest future the two areas in medical industry which will probably turn to blockchain technology are medication reconciliation and counterfeit medicines. Medication reconciliation is the process of creating the most accurate list possible of all medications a patient is taking — including drug name, dosage, frequency, and route — and comparing that list against the physician's admission, transfer, and/or discharge orders, with the goal of providing correct medications to the patient at all transition points within the hospital. Medication reconciliation, of course, is both prone to human error and time-consuming – and frequently redundant, as each provider collects much of the same information on each visit. On blockchains, data can be kept instantly up to date – and shared widely, including with pharmacies.

Counterfeit medicine is fake medicine. It may be contaminated or contain the wrong or no active ingredient. They could have the right active ingredient but at the wrong dose. Counterfeit drugs are illegal and may be harmful to your health. All organized societies taking counterfeits seriously and their primary goal is to protect the drug supply from the threat of counterfeits. In that fight blockchain technology could be a great ally and help to safeguard patients. A good case study that could also be extend to counterfeits is Modum.

Modum, created a solution based on Internet of Things (IoT) technology and blockchain, whereby the medicinal product delivery is monitored with sensors, with the sensor data collected during the logistics validated with blockchain. That medicinal products have been shipped in compliance to requirements. Modum's solution includes smart contracts to model required conditions and test that these rule are met. In case the temperature rises above

[13] S. Hogan, H. Fraser, P. Korsten, V. Pureswaran, and R. Gopinath, "Healthcare rallies for blockchains: Keeping patients at the center," *Ibm*, p. 21, 2016.

a predefined limit, a smart contract is triggered, and relevant parties are alerted. Blockchain ensures that logs are immutable and tamper-free

Another blockchain use case from the area of health industry is BloodChain. BloodChain, is an “open social blood bank” concept developed by Blodon. This concept is intended to form an extensive solution, a new kind of market mechanism for blood donation, incorporating BLOOD cryptocurrency. Donors are rewarded with BLOOD tokens, which can be used to acquire services in the network. The platform keeps a donor registry, which holds information about donors and their blood types. The network is based on public and private blockchain and an interfacing back-end system. In concept, public blockchain hosts BLOOD tokens, and the private blockchain is used as a secure indexing mechanism for donors. The donor data are held on a back-end system, and none of the personal sensitive data are exposed in blockchain. Among its missions are to ensure blood availability for all the needy, to radically reduce cost of blood storage and management and provide effective support for the less than 21 day shelf-life inventory strategy

The last use case that worth to be mentioned is My Health My Data (MHMD). It is an EU-funded research and innovation project, which is poised to be the first open biomedical information network centered on the connection between organizations and the individual, aiming at encouraging hospitals to start making anonymized data available for open research, while prompting citizens to become the ultimate owners and controllers of their health data.

5.5. Social Media

Intellectual property management is another field where the implementation of block chain based solutions could have an important impact. With the advent of internet, artists, authors and musicians one the one hand became more popular as their creations was easily widespread on the other hand saw their incomes reducing because of piracy. Another problem is the copyright protection and especially the proof of ownership from the inception time.

The creation of a registry based on distributed ledger technology could help artists to proof the time of first use. As we mentioned all blockchain transactions are timestamped and nobody can change those records. This would protect mainly young artists or businessmen who usually lose their rights because they haven't been registered yet and firms which have the means and funds take advantage of them. Publishing your idea in a blockchain registry would be a transparent proof to the whole world of the rightful intellectual property ownership.

First of all content creators and artists would digitalize their work and will monetize it. Afterwards can be distributed through a decentralized peer to peer platform based on digital money and smart contracts. A smart contract would trigger a payment every time a network user would use this record. Video and music streaming could be charged by minute or seconds of use. The payment will be sent directly to the author without any delays and avoiding any intermediaries. This would benefit mostly creations consist of more than one artists. Songs is such an example. The lyricist, the singer, the musicians, the music writer, the record company which made the production and so on. All stakeholders would agree from the very beginning on the terms which will be written in a smart contract. After that no other action is needed. Such solution would offer transparency between the coefficients and faster payment.

Nowadays plenty of such applications were created and already used. Mediachain is a peer to peer blockchain database which allow information to be shared among different organizations and platforms. Mediachain in 2017 was bought by Spotify in order to cut down the problem of loyalty payments and rights holders in music industry. Similarly Inmusic is a platform launched in 2019 in order to help artists to publish their music and interact like a social media platform directly with their fans. This blockchain platform has already registered 18.000 users. Finally Digimark developed a solution that could be used by creators of audio, visual and image content to license their intellectual property. Digimark created a barcode which work as a digital fingerprint and through the collection of metadata can measure the usage and estimate payments. Blockchain technology was integrated over the platform and the most famous user is production company Rovio who integrated to its application of Angry Birds to track the interactions with the music of the application.

Another media sector blockchain will change is social media. Such an example is Steemit. "*Steemit is a blockchain-based blogging and social media website, which rewards its*

users with the cryptocurrency STEEM for publishing and curating content[14]*"*. People can write and publish long blog posts and they can engage in extensive discussions and share content and links from anywhere on the internet. Posts are up voted or down voted and commented on by other users. This innovative business model provides motives to users to contribute high quality content and give feedback.

Similarly to Steemit, there is also D.tube which takes de-centralized social media a step further. It is a video sharing and streaming platform similar to YouTube which is built as an application on the Steem block chain. It operates under the same principles as Steemit content contributors, but they are sharing video rather than blog posts. The principles it operates on are the same as those of steam content contributors are rewarded in Steam's native crypto assets but the focus is on video rather than blog posts. D.Tube advertise its platform as an alternative of YouTube where there are no advertisements and no central authority can censorship the videos but only the users themselves. Furthermore, there is no algorithm controlling the visibility or monetization of certain videos over others.

It remains to be seen how such decentralized marketplaces will be develop in the future and whether they will be widely accepted by users. Regardless to any problems will face, thanks to blockchain technology we will likely see a significant disruption in the way artists manage their intellectual property in the future. Artists will have better opportunities to publish distribute and monetize their content on their own in an environment that also protects their Intellectual property rights.

[14] en.wikipedia.org, "Steemit." [Online]. Available: https://en.wikipedia.org/wiki/Steemit. [Accessed: 27-Jun-2019].

The picture represents blockchain initiatives per industry and sector

6. BLOCKCHAIN, AI and IOT SYNERGIES

Blockchain, Artificial Intelligence (AI) and the Internet Of Things (IOT) are the hottest technology trends nowadays. No wonder most companies and venture capital investors are interested in implementations of these technologies in various areas.

Both AI and IoT will change the world as we see it even without blockchain, but blockchain can act as a mediator which will boost the mass adoption of the other two technologies. Blockchain represents a new way of storing and sharing data, as well as doing transactions that is more secure and immutable than the current internet. Blockchain technology stores its data on participating peers, or computers, across its decentralized network, rather than in companies' central servers and computer rooms, thus giving the ability to stakeholders to do all the available audit at any time.

Blockchain, IoT and AI are perfectly suited to work together. Thus, the integration and interoperability of these technologies are set as top priority for developers. It is inevitable that those three technologies will eventually work together and the most important in a smooth way. For example, IoT will produce data for all the things happening around us. AI will give the opportunity to machines to take actions and make decisions based on the information produced by IoT in the absence of people to give instruction. Underlying all of this, blockchain networks could be recording, transferring and securing this information, hand it over to people in order to be better informed and help them in decision making.

6.1. Internet Of Things

"The Internet of things (IoT) is the extension of Internet connectivity into physical devices and everyday objects. Embedded with electronics, Internet connectivity, and other forms of hardware (such as sensors), these devices can communicate and interact with others

over the Internet, and they can be remotely monitored and controlled."[15] The basic idea is to interconnect through the internet different devices from our daily life so their tasks could be correlated.

Current IoT ecosystems are based on intermediary communication models (server – client) All devices are detected and authenticated and are connected through cloud servers. The same procedure is followed for all devices and sensors regardless of their distance. Extended IoT implementations are usually expensive because of infrastructure maintenance costs.

Blockchain technology has great potential to help the IoT as its devices (sensors, computers, phones, etc) need to transfer information safely from one to another. With the use of distributed ledger technology platforms, IoT won't need the central point of authority. Blockchain will enable secure and robust communication with all connected devices simultaneously. What is more, the information cannot be altered.

We have already seen in this paper some great examples where blockchain and Iot is cooperating to bring fabulous results. Supply chain management is the most benefited one because covers all spectra of economic and social life, from food industry, clothing, trade and health care.

6.2. Artificial Intelligence

"Artificial intelligence is intelligence demonstrated by machines, in contrast to the natural intelligence displayed by humans and animals. Colloquially, the term "artificial intelligence" is used to describe machines that mimic "cognitive" functions that humans associate with other human minds, such as "learning" and "problem solving" Modern machine capabilities generally classified as AI include successfully understanding human speech,

[15] en.wikipedia.org, "Internet of things." [Online]. Available: https://en.wikipedia.org/wiki/Internet_of_things. [Accessed: 27-Jun-2019].

competing at the highest level in strategic game systems (such as chess and Go) autonomously operating cars, intelligent routing in content delivery networks, and military simulations.[16]*"*

Artificial intelligence, although a very common buzz word currently, is not a brand-new concept. Research in that field started many years ago and what we have all expected was that in a very little time computers would be capable to replace any human job. Artificial intelligence didn't have the progress everyone expected due to limitations in computing power. Nowadays Artificial intelligence is pretty much everywhere as more sectors are increasingly driven by automation of tasks with smart algorithms.

From a business point of view, AI is all about automation, predictive analytics, and business process automation as to increase productivity and reduce corporate costs. Programming and algorithms are loaded with data from numerous real-world experiences in order to teach computers how to respond to certain scenarios. The ability to automate business practices and procedures, create new models and definitive decision making are some of the potential uses of AI. These innovations cover everything from intelligent retail management, sales systems, to AI enabled cybersecurity systems.

AI relies on large data sets for training and improving algorithms. Blockchain on the other uses a structure that enables data to move from peer to peer efficiently. Blockchain provides decentralization and distribution of data in an innovative and secure way with the use of cryptography. It can be used to optimize the efficiency of value transfer networks, asset registers and marketplaces. As it was already analyzed, a distributed ledger ensures that all parties the network are aligned at all times in regard to their past activities and current balances, as each new piece of information is updated simultaneously. The machine learning algorithms work better when data are collected from a data repository or a platform that is reliable, secure, trusted, and credible. When smart contracts are used for machine learning algorithms to make decisions and perform analytics, the outcome of these decisions can be trusted and undisputed.

There are some general-purpose projects combining AI and blockchain which are basically use blockchain technology to create decentralized marketplaces for AI algorithms,

[16] en.wikipedia.org, "Artificial intelligence." [Online]. Available: https://en.wikipedia.org/wiki/Artificial_intelligence. [Accessed: 27-Jun-2019].

data sets and shared computational resources for training such algorithms. The more futuristic concept of AI for smart contracts, which eventually can be used to build and run AI DApps and Decentralized Autonomous Organizations (DAOs) in such a way that they can adapt and evolve to complete tasks with very limited human intervention is also very interesting.

7. BLOCKCHAIN LEGAL PERSPECTIVE

The legal story of blockchain will follow more or less the same route as it happened with the technology itself. As we descripted everything started with cryptocurrencies and since it wasn't massively distributed and it was believed that this hidden currency was used for illegal things, nobody dealt to regulate the market.

The rise of blockchain and crypto assets caused significant headaches to regulators around the world. The problem with blockchain is that includes much more than just cryptocurrencies. Given the mix of currency, commodity and equity features blockchain is a complex matter and each case need to be confront differently. Everybody has heard of crypto currencies but when it comes to the use of the term many are confusing cryptocurrencies with crypto assets which is different.

The biggest challenge for regulators is how to set rules in markets to protect investors and users and also keep the technological innovation unhampered. And here this is a very challenging task because blockchain crypto assets are at the forefront of technology, finance economics and legal science at the same time. From a legal point of view, Blockchain must be examined from three different aspects. The first one is financial markets, the second one is trading and stakeholders' relations and the third one would be peoples' rights.

Financial markets and stock exchanges globally were the first took actions to protect the investors. As the crypto asset market is getting bigger and more corporations, institutions and investors are getting involved, financial market regulators trying to set adequate rules that balance the interests of all parties involved. On one hand they must assure that their rules maintain efficient and orderly capital markets which in turn allow companies to raise enough capital to fund their operations boost innovation and ultimately stimulate the economy. On the other hand they need to protect retail investors who most probably don't know anything about bitcoin and cryptocurrencies but they are getting involved because it seem profitable and it is trendy.

The second legal field need to be examined is that related to trading. What rules and regulations should be put in place, so that stakeholders will not face in the future any legal problem. What will happen in case of a smart contract either by accident or on purpose will be set wrong? How the two parties will solve this problem. Rules and regulations should be defined in order to allow trending of specific assets through blockchain in order this transaction to be legitimate.

As it was introduced already, many industries will be benefit from the implementation of smart contracts like the shipping and logistics industry, the banking industry, the insurance industry and the real estate industry, among others, including government and non-governmental organizations. All people dealing with industries aren't capable to understand, create or audit a smart contract and an expert will be needed. What kind of rules should be set to tackle this problem and parties will be sure that the code in the smart contract, when executed, accurately reflects the agreement of the parties?

We referred earlier in supply chain management. It is an industry that involve many stakeholders from different jurisdictions. In case a legal issue occur which will be the governing law? Which are the elements that will define it? According to opinions expressed in the European Union Blockchain Observatory & Forum workshop on Digital Assets, which took place in Brussels on 24 May, 2019, the basic idea summarized as follows: "*In terms of the legal framework underpinning digital assets, implementing and monitoring the rights given by a digital asset is currently generally handled through off-chain legal contracts. As people become more comfortable with smart contracts, we will see these become increasingly autonomous. It was also pointed out that in various national securities laws there are rules that can make it difficult for the issuance and trading of (decentralised) digital assets (for example, that contracts need to be on paper, or the mandatory use of CSDs). Another hurdle to mass adoption is the fact that, because these assets and platforms are so new, issuance can be more expensive than for traditional assets. This, however, should change over time*[17]*."*

[17] EU Blockchain Observatory & Forum, "Tangible intangibles: Digital assets on blockchain," *European Union*, 2019. [Online]. Available: https://www.eublockchainforum.eu/news/tangible-intangibles-digital-assets-blockchain. [Accessed: 27-Jun-2019].

The third aspect is the one that has to do with people rights and their personal data. What will happen with people's privacy? How these are protected and what will happen in case of a data breach? In different jurisdictions there are imposed special regulations in order to protect people privacy. In European Union, General Data Protection Regulation (GDPR) gives to the people the ultimate power to decide about their personal data and how those can be used. In the contrary one of blockchain key elements is its immutability, thus nothing can be erased or changed.

As it was recorded in the thematic report of European Union Blockchain Observatory and Forum, the right to be "forgotten" it isn't the only conflict between GDPR and Blockchain. There are issues when it comes to obligations of data controllers and processors. It is difficult some times to identify these two roles in blockchain implementations and as a result their obligations cannot be fulfilled. Another issue arises with personal data anonymization and what is the right output that can be stored in blockchain and be compatible with GDPR.

Although I'm not a lawyer, based on my experience in law enforcement and the opinions expressed in the workshop "Legal Recognition of Blockchains & Smart Contracts" in Paris, my opinion is that most of the above actions have been foreseen from the legislator, in terms of the current technology. What haven't been foreseen is that some of these actions could be executed with the use of blockchain and this is a legal vacuum that need to be covered. It is something that always happening when new technologies are coming to the forefront. What need to be done is governments directly understand the need for changes and have the reflexes to procced immediately to the enforcement of new regulations or amendments. Indeed such reactions occur and some positive initiatives have already been taken globally.

7.1. European Union

European Union had been seen the need of Internet rebuild, focused firstly to protect citizens' rights with the enactment of GDPR in May 2018, before moving on supporting the usage of digital signatures and smart contracts. After doing so, the European Union created its own bodies within the community in order to encourage the use of new technologies, while a

lot of European countries took their one initiatives in order to create the right rules and define the legal frame in which blockchain would operate. Some such examples are the following.

In April 2018, 22 countries of the European Union signed a declaration on the establishment of a European blockchain partnership. Mariah Gabrial commissioner for digital economy and society was the person who promoted the partnership and stated that she believes in the technology's potential to transform the digital world in the future.

In May 16 2018, Members of the European Parliament passed a blockchain resolution by the Industry, Research and Energy Committee which seeks to recognize the role blockchain can play in enhancing innovation in Europe and around the world. The resolution was introduced to the house by Eva Kaili. From a regulatory point of view, the legislator suggested a balanced innovation-friendly approach. She explained to the house that it was not the technology that needed to be regulated, but the uses per sector.

Later on the European Commission has launched the EU Blockchain Observatory and Forum, with the purpose of mapping key initiatives, monitoring developments and inspiring common actions. Within the forum it was created the Blockchain Policy and Framework Conditions Working Group. Is role is to look at cross-technology and cross-industry issues to define the policy, legal and regulatory conditions needed to promote the regulatory and legal predictability necessary for larger-scale deployment of blockchain applications.

Malta in May 2018 introduced three bills regarding Distributed Ledger Technology. One was a framework regulation for ICO operations and use of digital currencies, the framework for the registration of DLT Platform Operators and Controllers, as well as their certification, and the use of virtual currencies and DLTs from iGaming platforms.

The Federal Council of Switzerland in a report presented the amendments made in some acts in order to synchronize with new Blockchain technology. That included changes in civil law, insolvency law, financial market law and Anti-money Laundering law.

Cyprus is another example which not only regulated its stock market, it also promotes Blockchain technology by introducing the world’s first master’s degree for digital currencies.

7.2. Globally

Similar initiatives are taken all over the world. For example in World Economic Forum a center for the 4th Industrial Revolution is set, in order to check what are the policies interventions and which is the framework we are deploying new technologies like AI and Blockchain.

"The US has moved greatly on integrating cryptography and smart contracts into the statute on several states. At part of this the federal Electronic Signatures in Global and National Commerce Act (ESIGNAct) and the Uniform Electronic Transactions Act (UETA) aim to support the legal basis for the integration of legal contracts. Using these Acts as a foundation, on 3 April 2018, Arizona has defined that organization can now hold and share data on a blockchain. These amendments build on laws which recognize digital signatures and smart contracts as legal entities."[18] In the beginning of May 2019, USA FinCEN issued new guidance addressing cryptocurrency and other convertible virtual currency.

In March 2017, Australia released the "Roadmap for Blockchain Standards", which cemented its position as the country with the most advanced regulatory framework around the technology. On May 30 Australian Securities[19] and Investments Commission has issued updated regulatory guidance for businesses involved with ICOs and crypto assets. "These regulatory requirements are in place to maintain the integrity of Australia's financial market and ensure consumer protection," the regulator said.

And that are not the only examples, also Brazil, Hong Kong and Singapore regulated their financial markets. What is more, recently a group of U.S. lawmakers has urged advisors to President Donald Trump to include blockchain on their list of emerging technology initiatives.

[18] B. Buchanan and N. Naqvi, "The Journal of The British Blockchain Association," *J. Br. Blockchain Assoc.*, vol. 1, no. 1, pp. 1–4, 2018.
[19] Y. Khatri, "Australian Securities Watchdog Updates Guidance on ICOs and Crypto Assets - CoinDesk," *CoinDesk*, 2019. [Online]. Available: https://www.coindesk.com/australian-securities-watchdog-updates-guidance-on-icos-and-crypto-assets. [Accessed: 27-Jun-2019].

CONCLUSIONS

The world has seen several innovations that have radically transformed the way economic value was created and captured by individuals and company's inventions. The wheel, compass, steam, computer and the Internet have all played a major role in shaping the global economy. Thirty years ago the Internet came to the stage and in about ten years it was massively adopted. People quickly embraced it as another instrument to shorten the distance allowing them to communicate in real time.

Blockchain is one of the hottest topics in the world at the moment, and plenty projects are implemented mainly in private sector. From the use cases Blockchain is involved we are talking about a technology that is going to affect every industry in the world, from supply chain management, health care, food, financial markets, insurance to real estate and crowdfunding initiatives. Hence, why the bigger companies in the world such as Google, IBM, Microsoft, Walmart, Intel and Amazon are all trying to become early adopters of blockchain.

It is widely believed that the impact of blockchain in a decade or two from now would be quite profound. Chances are, it will disrupt the business world in a comparable way Internet did. This is a truly fascinating time to keep up with technological innovation. This isn't a question of if but more a question of when and how. Now is the time to consider how it can be applied and integrated into our world. CTO of Golden State foods, Mrs Guilda Javaheri, paraphrasing Victor's Hugo statement "*nothing is more powerful than an idea whose time has come*" said that "*Blockchain is an idea whose time has come*"

Blockchain simplifies and automates the compliance process, enabling real-time monitoring of financial activity between regulators and regulated entities. This increase integrity and transparency as all stakeholders can have access to a public record in real time. Blockchain provides the ability to autonomously execute financial agreements in a shared and trusted environment thus reducing clearing and settlement time of transaction verification and validation. Funds transferred faster between institutions and fraud actions are minimized, as

every transaction is recorded into a ledger that cannot be deleted or changed and is distributed to all peers.

Based on use cases that are already working, test projects and other experimentations taking place all over the globe, both in private and public sector, most likely is that in the next years the use of Distributed Ledger Technology will exponentially increasing. Like any emerging concept with significant potential benefits, blockchain is not applicable to every situation. Users and developers are still sorting out challenges both technological and managerial. The biggest disadvantage is the platform's scalability and when it comes to implementations with plenty transactions must be of a great consideration.

From the use cases examined during the elaboration of the current research it is concluded that the technology, despite the plurality of projects that have been developed, have just moved to its adolescence. Clearly, the use of technology beyond cryptocurrencies has solved problems initially found on the first applications, but the business sector is still experimenting in several areas to reach the desired point. Although plenty of initiatives were taken it is needed quite some time for mass adoption. Based on Everett Rogers theory "Diffusion of innovations" I would say that blockchain technology at the moment is passing from the early adopters to early majority but it still is in the beginning of the curve.

In addition, you can understand that the technology is still in its early stages from the fact that big companies with great expertise in their field are cooperating together in order to achieve the best possible result. As can be seen from the use cases examined, most of them consist of consortia and those applications created by smaller companies or startups are covering a low scale projects.

An additional conclusion from the analysis of the use cases included in the Appendix at the end of the paper, is that according to the field each application is going to cover, the corresponding technology is chosen. In particular, applications designed for banking sector are basically choosing R3 technology, those applications that need to include some kind of token in their solution prefer the Ethereum platform and finally the more commercial applications are tend to select the hyperledger technology.

Again, choosing to leverage blockchain is not just a technology question, it is a decision that can transform business models and processes, and reshape the set of stakeholders and their roles. Although innovative new technologies can make millions of people's daily lives simpler and more secure, in the upcoming years blockchain bet will be placed in public sector and whether governments are in a position to take initiatives for more extensive use, as part of their efforts to reduce government costs, improve security in an era of cyber uncertainty, and enhance their mission delivery.

According to a WEF (2016) study, blockchain technology is not a panacea, but one of many technologies that could form a foundation for the next generation of financial services infrastructure. The regulatory environment, even though a lot of actions has been made, is still uncertain and un-harmonized. The European Union is certainly investigating the issue, committing millions of Euros to study benefits, including the recent creation of the EU Blockchain Observatory and Forum, with the support of the European Parliament.

Furthermore, careful consideration must be given on the use of Blockchain when rules of GDPR are applied. Obligations of data controllers and processors as well as persons right to be "forgotten" should be taken seriously during the implementation as to avoid future disharmonies and irregularities.

Governments must work in collaboration with civil society, academia and the private sector to co-develop policy with a process that is as dynamic as technology. Policy makers and the regulatory processes they use, need to be reimagined to be as agile as the technology they seek to regulate, in order to help create the future we all want to see. Finally also people should be actively engaged with new implementations in order to understand also their perspective of the problems they are dealing with. Systems of the future should be built with the community rather than for the community

REFERENCES

[1] C. Alexopoulos, Y. Charalabidis, A. Androutsopoulou, M. A. Loutsaris, and Z. Lachana, "Benefits and Obstacles of Blockchain Applications in e-Government," *Proc. 52nd Hawaii Int. Conf. Syst. Sci.*, pp. 3377–3386, 2019.

[2] J. Al-Jaroodi and N. Mohamed, "Blockchain in Industries: A Survey," *IEEE Access*, vol. 7, pp. 36500–36515, 2019.

[3] A. Alketbi, Q. Nasir, and M. A. Talib, "Blockchain for government services-Use cases, security benefits and challenges," *2018 15th Learn. Technol. Conf. L T 2018*, pp. 112–119, 2018.

[4] M. Attaran, "Blockchain-Enabled Technology: The Emerging Technology Set to Reshape and Decentralize Many Industries," *Int. J. Appl. Decis. Sci.*, vol. 12, no. 1, p. 1, 2019.

[5] M. Attaran and A. Gunasekaran, "Blockchain-enabled technology: the emerging technology set to reshape and decentralise many industries," 2019.

[6] A. Baliga, "Understanding Blockchain Consensus Models," *Whitepaper*, no. April, pp. 1–14, 2017.

[7] blockchain-council.org, "Blockchain Council / About us." [Online]. Available: https://www.blockchain-council.org/about-us/. [Accessed: 27-Jun-2019].

[8] G. A. Bowen, "Document Analysis as a Qualitative Research Method," *Qual. Res. J.*, vol. 9, no. 2, pp. 27–40, 2009.

[9] B. Buchanan and N. Naqvi, "The Journal of The British Blockchain Association," *J. Br. Blockchain Assoc.*, vol. 1, no. 1, pp. 1–4, 2018.

[10] C. Cachin, "Architecture of the Hyperledger Blockchain Fabric," *Work. Distrib. Cryptocurrencies Consens. Ledgers (DCCL 2016)*, vol. URL:, p. https://www.zurich.ibm.com/dccl/papers/cachin_dccl, 2016.

[11] I. Cano Aguilar, "Opinion of the European Economic and Social Committee on the 'Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: eHealth Action Plan 2012-20 — Innovative," *Off. J. Eur. Union*, pp. 122–126, 2013.

[12] I. CB Information Services, "What ' S Next in Blockchain," 2019.

[13] G. Chen, B. Xu, M. Lu, and N.-S. Chen, “Exploring blockchain technology and its potential applications for education.”

[14] U. Chohan, “The Decentralized Autonomous Organization and Governance Issues,” *Ssrn*, 2017.

[15] N. Diallo *et al.*, “EGov-DAO: A Better Government using Blockchain based Decentralized Autonomous Organization,” *2018 5th Int. Conf. eDemocracy eGovernment, ICEDEG 2018*, pp. 166–171, 2018.

[16] D. Efanov and P. Roschin, “The all-pervasiveness of the blockchain technology,” *Procedia Comput. Sci.*, vol. 123, pp. 116–121, 2018.

[17] J. Erbguth and J. H. Morin, “Towards Governance and Dispute Resolution for DLT and Smart Contracts,” *Proc. IEEE Int. Conf. Softw. Eng. Serv. Sci. ICSESS*, vol. 2018-Novem, pp. 46–55, 2019.

[18] Ernst & Young, “Implementing Blockchains and distributed Infrastructure,” p. 8, 2016.

[19] A. G. Fallis, “EU eGovernment Action Plan 2016-2020,” *Eur. Comm.*, no. 2016, 2016.

[20] V. Gatteschi, F. Lamberti, C. Demartini, C. Pranteda, and V. Santamaría, “Blockchain and smart contracts for insurance: Is the technology mature enough?,” *Futur. Internet*, vol. 10, no. 2, pp. 8–13, 2018.

[21] F. Glaser, “Pervasive Decentralisation of Digital Infrastructures: A Framework for Blockchain enabled System and Use Case Analysis,” *Proc. 50th Hawaii Int. Conf. Syst. Sci.*, pp. 1543–1552, 2017.

[22] S. Hogan, H. Fraser, P. Korsten, V. Pureswaran, and R. Gopinath, “Healthcare rallies for blockchains: Keeping patients at the center,” *Ibm*, p. 21, 2016.

[23] D. J. Hosp, “Blockchain 2.0,” *Fbv*, no. January, 2018.

[24] C. Jentzsch, “Decentralized Autonomous Organization to Automate Governance,” *White Pap.*, pp. 1–30, 2016.

[25] E. F. Jesus, V. R. L. Chicarino, C. V. N. de Albuquerque, and A. A. de A. Rocha, “A Survey of How to Use Blockchain to Secure Internet of Things and the Stalker Attack,” *Secur. Commun. Networks*, vol. 2018, pp. 1–27, 2018.

[26] M. N. Kamel Boulos, J. T. Wilson, and K. A. Clauson, “Geospatial blockchain: promises, challenges, and scenarios in health and healthcare.,” *Int. J. Health Geogr.*, vol. 17, no. 1, p. 25, 2018.

[27] A. Kapitonov *et al.*, “Robotic Services for New Paradigm Smart Cities Based on Decentralized Technologies,” *Ledger*, vol. 4, 2019.

[28] J. Killmeyer, M. White, and B. Chew, “Will blockchain transform the public sector?,” *Deloitte Univ. Press*, 2017.

[29] T. T. Kuo, H. E. Kim, and L. Ohno-Machado, “Blockchain distributed ledger technologies for biomedical and health care applications,” *J. Am. Med. Informatics Assoc.*, vol. 24, no. 6, pp. 1211–1220, 2017.

[30] T. T. Kuo, H. Zavaleta Rojas, and L. Ohno-Machado, “Comparison of blockchain platforms: A systematic review and healthcare examples,” *J. Am. Med. Informatics Assoc.*, vol. 26, no. 5, pp. 462–478, 2019.

[31] L. Lamport, R. Shostak, and M. Pease, “The Byzantine Generals Problem,” *ACM Trans. Program. Lang. Syst.*, vol. 4, no. 3, pp. 382–401, 1982.

[32] L. Lamport, R. Shostak, and M. Pease, “The Byzantine Generals Problem,” *ACM Trans. Program. Lang. Syst.*, vol. 4, no. 3, pp. 382–401, 1982.

[33] C. K. LEE, “Blockchain Application with Health Token in Medical & Health Industrials,” in *2nd International Conference on Social Science, Public Health and Education*, 2019, vol. 196, no. Ssphe 2018, pp. 233–236.

[34] L. Liu, C. Wu, J. Xiao, and L. Liu, “EasyChair Preprint Blockchain-Based platform for Distribution AI Blockchain-Based platform for Distribution AI,” 2019.

[35] E. Loukis, Y. Charalabidis, and L. S. Flak, “Introduction to the Minitrack on Towards Government 3.0: Disruptive ICTs, Advanced Policy Informatics/Analytics and Government as a Platform,” *Proc. 52nd Hawaii Int. Conf. Syst. Sci.*, 2019.

[36] T. Lyons, “EU BLOCKCHAIN OBSERVATORY & FORUM Workshop Report - Legal Recognition of Blockchains & Smart Contracts,” 2018.

[37] T. Lyons, L. Courcelas, and K. Timsit, “Blockchain and the GDPR,” pp. 4–31, 2018.

[38] M. Macdonald, L. Liu-Thorrold, and R. Julien, “The Blockchain: A Comparison of Platforms and Their Uses Beyond Bitcoin,” no. February, pp. 1–18, 2017.

[39] T. K. Mackey *et al.*, “‘Fit-for-purpose?’ - Challenges and opportunities for applications of blockchain technology in the future of healthcare,” *BMC Med.*, vol. 17, no. 1, pp. 1–17, 2019.

[40] J. Mattila, “The blockchain phenomenon - The Disruptive Potential of Distributed Consensus Architectures,” *BRIE Work. Pap. 2016-1*, vol. 2420, no. May 2016, pp. 1–25, 2016.

[41] Observatory of Public Sector Innovation OPSI - OECD, “Blockchain and its Use in the Public Sector,” 2018.

[42] L. Ojomoko *et al.*, “Converging blockchain and next-generation artificial intelligence technologies to decentralize and accelerate biomedical research and healthcare,” *Oncotarget*, vol. 9, no. 5, pp. 5665–5690, 2017.

[43] H. Para, A. Gir, G. N. Reddy, and K. Takkellapati, “Enhancing the Security And Authenticity of Insurance Claims Using Blockchain Technology Overview :”

[44] C. I. Payments, “Interbank Payments,” no. November, 2018.

[45] F. Report, *Evaluation of Regulatory Tools for Enforcing Online Gambling Rules and Channelling Demand towards Controlled Offers*, no. 641. 2018.

[46] K. Salah, M. H. U. Rehman, N. Nizamuddin, and A. Al-Fuqaha, “Blockchain for AI: Review and open research challenges,” *IEEE Access*, vol. 7, pp. 10127–10149, 2019.

[47] Satoshi Nakamato, “Bitcoin: A Peer-toPeer Electronic Cash System,” pp. 1–9, 2013.

[48] M. Sep and H. Pdf, “Blockchain and GDPR,” vol. 1, no. 1, pp. 8–23, 2015.

[49] D. Shrier, W. Wu, and A. Pentland, “Blockchain & Infrastructure,” *MIT Connect. Sci.*, pp. 1–18, 2016.

[50] M. Swan, *Blockchain : Blueprint for a New Economy*, First. O’Reilly Media, Inc, 2015.

[51] The Federal Council of Switzerland, “Legal framework for distributed ledger technology and blockchain in Switzerland. An overview with a focus on the financial sector,” no. December, pp. 1–162, 2018.

[52] A. R. Transfer, “Press Release Blockchain technology successfully piloted by,” pp. 1–3, 2016.

[53] L. J. Trautman and M. Molesky, “A Primer for Blockchain,” *SSRN Electron. J.*, pp. 1–48, 2019.

[54] F. Tschorsch and B. Scheuermann, “Bitcoin and beyond: A technical survey on decentralized digital currencies,” *IEEE Commun. Surv. Tutorials*, vol. 18, no. 3, pp. 2084–2123, 2016.

[55] USA Department of Homeland Security, “Blockchain and Suitability for Government Applications,” 2018.

[56] M. Valenta and P. Sandner, “Comparison of Ethereum, Hyperledger Fabric and Corda,” *Frankfurt Sch. Blockchain Cent.*, no. June, p. 8, 2017.

[57] P. Velye and L. Thomas, “the Impact of Auditor Rotation, Audit Firm Rotation and Non-Audit Services on Earnings Quality, Audit Quality and Investor Perceptions: a Literature Review,” *J. Gov. Regul.*, vol. 7, no. 2, pp. 74–93, 2018.

[58] Vitalik Buterin, “a Next Generation Smart Contract & Decentralized Application Platform,” no. January, pp. 1–36, 2009.

[59] P. Yeoh, “Regulatory issues in blockchain technology,” *J. Financ. Regul. Compliance*, vol. 25, no. 2, pp. 196–208, 2017.

[60] J. Yli-Huumo, D. Ko, S. Choi, S. Park, and K. Smolander, “Where Is Current Research on Blockchain Technology?—A Systematic Review,” *PLoS One*, vol. 11, no. 10, p. e0163477, Oct. 2016.

[61] S. Zaremba, A. Bubiel, A. Tkacz, R. Lugowicz, and A. Sosnowski, “BloodChain whitepaper,” 2017.

[62] R. Zhang, R. Xue, and L. Liu, “Security and Privacy on Blockchain,” vol. 1, no. 1, 2019.

[63] J. L. Zhao, S. Fan, and J. Yan, “Overview of business innovations and research opportunities in blockchain and introduction to the special issue,” *Financ. Innov.*, vol. 2, no. 1, pp. 1–7, 2016.

[64] “Tradelens Ecosystem | Connecting the global supply ecosystem,” *Tradelens.com*. [Online]. Available: https://www.tradelens.com/ecosystem/. [Accessed: 27-Jun-2019].

[65] “What is an escrow account?,” *Escrow.com*. [Online]. Available: https://www.escrow.com/what-is-an-escrow-account. [Accessed: 27-Jun-2019].

[66] “About DTube,” *DTUBE*. [Online]. Available: https://about.d.tube/. [Accessed: 27-Jun-2019].

[67] “Block size limit controversy.” [Online]. Available: https://en.bitcoin.it/wiki/Block_size_limit_controversy. [Accessed: 27-Jun-2019].

[68] “Factom | A Blockchain Innovations Company,” *FACTOM*. [Online]. Available: https://www.factom.com/. [Accessed: 27-Jun-2019].

[69] “What is a Smart Contract? Auto enforceable Code - Blockchain,” *blockchainhub.net*. [Online]. Available: https://blockchainhub.net/smart-contracts/. [Accessed: 27-Jun-2019].

[70] "Medication Reconciliation to Prevent Adverse Drug Events," *Institute of Healthcare Improvement*. [Online]. Available: http://www.ihi.org/Topics/ADEsMedicationReconciliation/Pages/default.aspx. [Accessed: 27-Jun-2019].

[71] "What is DAO - Decentralized Autonomous Organizations," *blockchainhub.net*. [Online]. Available: https://blockchainhub.net/dao-decentralized-autonomous-organization/. [Accessed: 27-Jun-2019].

[72] "European Parliament passes a blockchain resolution," *OpenAccessGovernment*, 2018. [Online]. Available: https://www.openaccessgovernment.org/european-parliament-passes-a-blockchain-resolution/45913/. [Accessed: 27-Jun-2019].

[73] "Hyperledger – Open Source Blockchain Technologies," *The Linux Foundation*. [Online]. Available: https://www.hyperledger.org/. [Accessed: 27-Jun-2019].

[74] 365 Careers, Creating opportunities for Business & Finance students, "Blockchain for business 2019: The new industrial revolution" [Online]. Available: www.udemy.com [Accessed: 27-Jun-2019].

[75] ACCENTURE, "Jasper - Ubin Design Paper / Enabling Cross-Border High Value Transfer Using Distributed Ledger Technologies," 2019.

[76] Blog.cosmos.network, "Consensus Compare: Casper vs. Tendermint." [Online]. Available: https://blog.cosmos.network/consensus-compare-casper-vs-tendermint-6df154ad56ae. [Accessed: 27-Jun-2019].

[77] D. Bradbury, "Blockchain project settles cross-border payment," *Sophos Ltd - NakedSecurity*, 2019. [Online]. Available: https://nakedsecurity.sophos.com/2019/05/07/blockchain-project-settles-cross-border-payment/. [Accessed: 27-Jun-2019].

[78] Corda Enterprise, "A Next Gen Blockchain Platform for Business | R3," *R3.com*. [Online]. Available: https://www.r3.com/platform/. [Accessed: 27-Jun-2019].

[79] B. Curran, "Blockchain Games: The Current State of Blockchain Gaming Technology," *Blockonomi.com*, 2019. [Online]. Available: https://blockonomi.com/blockchain-games/. [Accessed: 27-Jun-2019].

[80] O. Dale, "Beginner's Guide to WAX: Worldwide Asset eXchange for Video Game Virtual Goods," *Blockonomi.com*, 2018. [Online]. Available: https://blockonomi.com/wax-guide/. [Accessed: 27-Jun-2019].

[81] S. Daley, "17 Blockchain Music Companies You Should Know," *BUILT IN*, 2019. [Online]. Available: https://builtin.com/blockchain/blockchain-music-Innovation-examples. [Accessed: 27-Jun-2019].

[82] Digital Single Market and DIGIBYTE, “European countries join Blockchain Partnership,” *European Commission*, 2018. [Online]. Available: https://ec.europa.eu/digital-single-market/en/news/european-countries-join-blockchain-partnership. [Accessed: 27-Jun-2019].

[83] T. and C. (Directorate H. Digital Society, “Creating a digital society | Digital Single Market,” *European Commission*, 2018. [Online]. Available: https://ec.europa.eu/digital-single-market/en/policies/creating-digital-society. [Accessed: 27-Jun-2019].

[84] L. Dong, “What’s the future of blockchain in China?,” *World Economic Forum*, 2018. [Online]. Available: https://www.weforum.org/agenda/2018/01/what-s-the-future-of-blockchain-in-china. [Accessed: 27-Jun-2019].

[85] M. Down, “The New Blockchain Publishing Platform That Could Kill Medium and Steemit,” *HACKERNOON*, 2019. [Online]. Available: https://hackernoon.com/blockchain-publishing-publish0x-cryptocurrency-kill-medium-steemit-3fb0661dc9a. [Accessed: 27-Jun-2019].

[86] en.wikipedia.org, “Artificial intelligence.” [Online]. Available: https://en.wikipedia.org/wiki/Artificial_intelligence. [Accessed: 27-Jun-2019].

[87] en.wikipedia.org, “Consensus_(computer_science).” [Online]. Available: https://en.wikipedia.org/wiki/Consensus_(computer_science). [Accessed: 27-Jun-2019].

[88] en.wikipedia.org, “Internet of things.” [Online]. Available: https://en.wikipedia.org/wiki/Internet_of_things. [Accessed: 27-Jun-2019].

[89] en.wikipedia.org, “Steemit.” [Online]. Available: https://en.wikipedia.org/wiki/Steemit. [Accessed: 27-Jun-2019].

[90] EU Blockchain Observatory & Forum, “Tangible intangibles: Digital assets on blockchain,” *European Union*, 2019. [Online]. Available: https://www.eublockchainforum.eu/news/tangible-intangibles-digital-assets-blockchain. [Accessed: 27-Jun-2019].

[91] Frontier Of The Law, “A Blockchain Primer for Lawyers,” 2019. [Online]. Available: http://frontierofthelaw.com/2019/01/08/a-blockchain-primer-for-lawyers/. [Accessed: 27-Jun-2019].

[92] Golden State Foods, “GSF Partners with IBM to Go the Extra Mile with Blockchain - ,” *Golden State Foods*. [Online]. Available: https://goldenstatefoods.com/news/gsf-partners-ibm-go-extra-mile-blockchain/. [Accessed: 27-Jun-2019].

[93] IBM, “IBM Watson Health Announces Collaboration to Study the Use of Blockchain Technology for Secure Exchange of Healthcare Data - United States,” 2017.

[94] IBM Blockchain, “IBM Food Trust | IBM,” *IBM*. [Online]. Available: https://www.ibm.com/blockchain/solutions/food-trust. [Accessed: 27-Jun-2019].

[95] Y. Kazeem, “The world’s first blockchain-powered elections have just happened in Sierra Leone |,” *World Economic Forum*, 2018. [Online]. Available: https://www.weforum.org/agenda/2018/03/the-world-s-first-blockchain-powered-elections-just-happened-in-sierra-leone. [Accessed: 27-Jun-2019].

[96] F. Keller, “Blockchain-based Batavia platform set to rewire global trade finance,” *Blockchain Pulse: IBM Blockchain Blog*, 2018. [Online]. Available: https://www.ibm.com/blogs/blockchain/2018/04/blockchain-based-batavia-platform-set-to-rewire-global-trade-finance/. [Accessed: 27-Jun-2019].

[97] Y. Khatri, “Australian Securities Watchdog Updates Guidance on ICOs and Crypto Assets - CoinDesk,” *CoinDesk*, 2019. [Online]. Available: https://www.coindesk.com/australian-securities-watchdog-updates-guidance-on-icos-and-crypto-assets. [Accessed: 27-Jun-2019].

[98] G. Konstantopoulos, “Understanding Blockchain Fundamentals, Part 2: Proof of Work & Proof of Stake,” *Medium Corporation*, 2017. [Online]. Available: https://medium.com/loom-network/understanding-blockchain-fundamentals-part-2-proof-of-work-proof-of-stake-b6ae907c7edb. [Accessed: 27-Jun-2019].

[99] KPMG Services Pte. Ltd, “Cross-Border Interbank Payments and Settlements: Emerging opportunities for digital transformation,” 2018.

[100] P. Kravchenko, “Ok, I need a blockchain, but which one?,” *Medium Corporation*, 2016. [Online]. Available: https://medium.com/@pavelkravchenko/ok-i-need-a-blockchain-but-which-one-ca75c1e2100. [Accessed: 27-Jun-2019].

[101] S. Moser, “How Cyprus Is Becoming the Next Blockchain Hotspot,” *ENTREPRENEUR*, 2019. [Online]. Available: https://www.entrepreneur.com/article/325502. [Accessed: 27-Jun-2019].

[102] H. Polke, M. Burns, and S. Glavan, “Blockchain technology successfully piloted by Allianz Risk Transfer and Nephila for catastrophe swap,” 2016.

[103] H. Polke, K. Mateu, N. Das, and N. Schurtenberger, “Press release Allianz pioneers blockchain prototype for the captive insurance market,” 2017.

[104] RESET, “How Finland is Using the Blockchain to Revolutionise Financial Services for Refugees - Finland | ReliefWeb,” *Reliefweb*, 2018. [Online]. Available:

https://reliefweb.int/report/finland/how-finland-using-blockchain-revolutionise-financial-services-refugees. [Accessed: 27-Jun-2019].

[105] A. Shontell, "Jamie Dimon shareholder letter and silicon valley," *Business Insider*, 2015. [Online]. Available: https://www.businessinsider.com/jamie-dimon-shareholder-letter-and-silicon-valley-2015-4. [Accessed: 27-Jun-2019].

[106] M. Sokol, "Why I Left the Steem Blockchain," *Medium Corporation,* 2018. [Online]. Available: https://medium.com/@heymattsokol/why-i-left-the-steem-blockchain-bb0214a451b8. [Accessed: 27-Jun-2019].

[107] I. Stavrinos, "Malta is the pioneer in setting up DLTs- Hellenic Blockchain Hub (EL)," *Medium Corporation,* 2018. [Online]. Available: https://medium.com/hellenic-blockchain-hub-el/η-μάλτα-πρωτοπορεί-στη-ρύθμιση-των-dlt-a423154f08c0. [Accessed: 27-Jun-2019].

[108] The World Bank/IBRD-IDA "Innovation & Entrepreneurship" [Online]. Available: https://www.worldbank.org/en/topic/innovation-entrepreneurship. [Accessed: 27-Jun-2019].

[109] The Economist Intelligence Unit of IBM, "Healthcare rallies for blockchains. Keeping patients at the center," 2017.

[110] U.S Department of Homeland Security/CISA, "Understanding Denial-of-Service Attacks." [Online]. Available: https://www.us-cert.gov/ncas/tips/ST04-015. [Accessed: 27-Jun-2019].

[111] U.S FOOD & DRUG Administration, "Counterfeit Medicine," *United States Governement*. [Online]. Available: https://www.fda.gov/drugs/buying-using-medicine-safely/counterfeit-medicine. [Accessed: 27-Jun-2019].

[112] YouTeam Editorial Team, "10 Use Cases of Blockchain Technology in Banking," *YouTeam,* 2018. [Online]. Available: https://youteam.co.uk/blog/10-use-cases-of-blockchain-technology-in-banking/. [Accessed: 27-Jun-2019].

APPENDIX

PROJECT	Government / Commercial	Industry	Category	Permission	TOKEN	Blockchain Platform	DETAILS	Link
Storj.io Tardigrade.io	Commercial	Information Technology	File Storage	no	yes	Storj network	With Tardigrade cloud storage, your files are encrypted and split into pieces client-side before being distributed across our network of high-performance storage nodes.The STORJ token is used to provide incentives for storage node operators to contribute stable, performant, long-term storage and bandwidth to the network.	https://storj.io/blog/2018/12/an-overview-of-tokens-uses-flows-and-policies-at-storj-labs/ 2)https://storj.io/Storj-White-Paper-Executive-Summary.pdf 3)https://storj.io/
filecoin	Commercial	Information Technology	File Storage	no	yes	Filecoin protocol over IPFS	Filecoin is a decentralized storage network that turns cloud storage into an algorithmic market. The market runs on a blockchain with a native protocol token ("Filecoin"), which miners earn by providing storage to clients. Conversely, clients spend Filecoin hiring miners to store or distribute data	1)https://filecoin.io/ 2)https://filecoin.io/filecoin.pdf
DHL - Acenture	Commercial	Supply Chain Management	pharmaceuticals	yes	no		The partners have established a blockchain-based track-and-trace serialization prototype comprising a global network of nodes across six geographies. The system comprehensively documents each step that a pharmaceutical product takes on its way to the store shelf and eventually the consumer. The prototype was a lab performance simulation that demonstrated how blockchain technology could handle volumes of more than 7 billion unique pharmaceutical serial numbers and over 1,500 transactions per second.	https://www.logistics.dhl/content/dam/dhl/global/core/documents/pdf/glo-core-blockchain-trend-report.pdf 2)https://newsroom.accenture.com/news/dhl-and-accenture-unlock-the-power-of-blockchain-in-logistics.htm
Vechain	Commercial	Supply Chain Management	fashion	yes	yes / no	VeChainThor platform	VeChain's solution aims to build up a product traceability solution covering the life-cycle of products from the manufacturing, logistics and supply chain, retail and wholesale, after service, and even consumer engagement on blockchain for anti-counterfeiting along with IoT technologies. Fashion and luxury brands have already put our solution in place for live products and are enjoying the benefits of great reductions in counterfeit activities.	file:///C:/Users/JRPLPT/Downloads/vechainthor_development_plan_and_whitepaper_en_v1.0.pdf https://www.youtube.com/watch?v=RhZ7CMYrplw

PROJECT	Government / Commercial	Industry	Category	Permission	TOKEN	Blockchain Platform	DETAILS	Link
IBM world wire	Commercial	Banking	Cross border payments	yes	yes	Stellar protocol	Introducing IBM Blockchain World Wire, the new financial rail that simultaneously clears and settles cross-border payments in near real-time. Integrating with your existing payment systems, you'll replace costly opacity with affordable transparency – and that can bring greater financial opportunity to all. 72 countries, 47 currencies, 44 banking endpoints and more than 1081 unique currency trading pairs.	https://www.ibm.com/blockchain/solutions/world-wire
IBM Food Trust	Commercial	Supply Chain Management	food safety	yes	no	Fabric	IBM Food Trust, using blockchain technology running on the IBM Cloud, can connect growers, processors, distributors and retailers through a permissioned, permanent and shared record of food-system data that can drastically cut the time needed to trace produce from farm to store. In a pilot program, tracing time was reduced from almost seven days to just 2.2 seconds.better regulation on food industry	https://www.ibm.com/annualreport/2018/walmart.html http://thinktank.omfif.org/ibm
United Nations / Building Blocks	Government	Humanity	food program	yes	yes	Ethereum	The UN World Food Program's (WFP) Building Blocks pilot is using blockchain at refugee camps throughout Jordan. Refugees can now enter grocery stores and buy food by simply looking at a small machine by the cash register: an iris scanner that reads refugees' biometric data, then accurately accesses and spends WFP food vouchers from their linked accounts.The United Nations World Food Programme (WFP) is expanding its blockchain testing from refugee aid in the Middle East to supply chain management in Africa. Specifically, the new project will monitor the movement of food from Djibouti's port, where the WFP receives shipments, to Ethiopia, where much of its food operations are located.	https://innovation.wfp.org/project/building-blocks https://foodtank.com/news/2019/01/the-world-food-program-fighting-hunger-with-blockchain/ https://www.coindesk.com/un-food-program-to-expand-blockchain-testing-to-african-supply-chain
United Nations (UNOPS) and Republic of Moldova	Government	Humanity	trafficking	yes	no	Ethereum	A first in the world, this challenge aims at using blockchain technology to help combat child trafficking in the Republic of Moldova. The Ethereum platform presents an opportunity to create blockchain-based identity systems that seek to alleviate the systemic causes of human trafficking, making it virtually impossible for data on the system to be improperly manipulated by unauthorized actors. Working with agencies and stakeholders on the ground will be key to deploying innovative blockchain solutions addressing this humanitarian challenge	https://www.un.org/press/en/2018/pi2224.doc.htm

PROJECT	Government / Commercial	Industry	Category	Permission	TOKEN	Blockchain Platform	DETAILS	Link
Briliant Earth and Dharmanandan Diamonds	Commercial	Supply Chain Management	jewlery	yes		Everledger	The cutting-edge blockchain-based technology has been integrated with our supply chain to seamlessly and securely track gemstone origin and provide greater consumer assurance for responsible practices for a collection of blockchain enabled diamonds. Appealing to customers that are interested in learning more about how and where their products are sourced, Brilliant Earth's website now highlights the journey of blockchain-enabled diamonds, including additional information throughout the cutting and polishing process.	https://www.everledger.io/pdfs/Press-release-Brilliant-Earth-&-Everledger-bring-blockchain-diamonds-to-market.pdf https://www.brilliantearth.com/blockchain-diamonds-search/
Braid movie / ConsenSys	commercial	Entertainment	Movie ICO	no	yes	Ethereum / WeiFund	'Braid' is the First Feature Movie Fully Funded by Crypto. Film and cryptocurrency have finally come together. This year's Tribeca Film Festival will feature the indie hit Braid, a psychological horror film that's allegedly the first feature to be completely funded "through an Ethereum crowd sale."	https://media.consensys.net/making-dreams-our-reality-braid-the-movie-crowdfunding-campaign-93592921ebc4 https://bitsonline.com/braid-film-crypto-2/
Rentberry	commercial	Economy	Property rental	no	yes	Ethereum	Rentberry is a long-term rental platform that's utilizing blockchain technology to streamline the rental process for tenants and landlords alike. Using smart contracts, they provide unique features to users such as crowdsourced rental deposits and auctioned rental prices.	https://coincentral.com/rentberry-ico-analysis/
Siera Leone	Government	Politics	Voting	yes	yes	Agora Blockchain	Agora obtained permission from the NEC to act as "an international observer" at 280 of roughly 11,200 polling stations. Sierra Leone election officials recorded the paper votes as they would in any other election. Then, Agora's team recorded those same votes on its blockchain. Later, it published those results on its website. Essentially, Agora's involvement with the Sierra Leone election was a proof-of-concept experiment.	https://futurism.com/sierra-leone-election-blockchain-agora
Japanese city of Tsukuba	Government	Politics	Voting	yes	no		The first-of-its-kind digital vote in Japan, Tsukuba will use Japan's "My Number" system - a 12-digit social security identifier afforded to all Japanese residents – to verify voters' credentials before securing the vote from being falsified or accessed through decentralized blockchain technology. Voters were asked to place their My Number card on a card reader before casting their vote while selecting the program of their choice. The vote was then recorded on a decentralized ledger whilst making it immune from tampering, according to the report	https://www.ccn.com/in-a-first-japanese-city-deploys-online-blockchain-voting-system/

PROJECT	Government / Commercial	Industry	Category	Permission	TOKEN	Blockchain Platform	DETAILS	Link
Nauka World / Socrates coin	Commercial	knowledge	Education	no	yes	Ethereum	SocratesCoin is the the currency of the knowledge industry. Provides a transparent and secured distributed ledger data infrastructure. It is the currency of choice for Nauka World. Nauka World is the virtual reality enabled global education platform together with a Science to Industry ecosystem. Nauka World provides the world's leading scientific education enabling a lifelong creation of deep learning and knowledge transference. We are pleased to announce a rich platform of digital currency, scientific breakthrough, Virtual Reality education technologies and job creation capabilities for the next century of leadership.	
Basic Attention token	Commercial	Economy	Digital Advertisment	no	yes	Ethereum	Basic Attention Token radically improves the efficiency of digital advertising by creating a new token that can be exchanged between publishers, advertisers, and users. The token can be used to obtain a variety of advertising and attention-based services on the BAT platform. The utility of the token is based on user attention, which simply means a person's focused mental engagement.	https://basicattentiontoken.org/BasicAttentionTokenWhitePaper-4.pdf https://basicattentiontoken.org/
Waltonchain	commercial	Supply Chain Management	Internet of things	no	yes		Waltonchain combines blockchain technology with Internet of things. The objective is to manage supply chains based on RFID (radio-frequency identification) technology. RFID automatically identifies and tracks tags that contain data about product info, location and other relevant product data.The first branch of the introduction of the new platform at the first stage was the companies of the clothing industry of China.	https://en.bitcoinwiki.org/wiki/Walton
BenBen / Ghana	Government	Public Sector	land property	yes	no	Ethereum	This platform captures transactions and verifies the data. BenBen works with financial institutions to update current registries, enable smart transactions and distribute private keys for clients - to allow an automated and trusted property transactions between all parties. It aggregates all the information such that financial institutions and the Lands Commission have real-time access to the data	https://www.bigchaindb.com/usecases/government/benben/
Vehicle Wallet	Government / Commercial	Public Sector	taxes				Vehicle Wallet is a partnership between payment service provider and the Danish Tax Administration. It is a supply chain management tool where data concerning the car is saved in one distributed ledger and creates one agreed and shared record of the vehicle history as it is transferred across the supply chain. This reduces risks for buyers and sellers, and helps ensure Denmark receives all proper taxes.	https://www.intelligenthq.com/how-governments-are-adopting-blockchain-and-ai-in-advanced-economies-part-2/

PROJECT	Government / Commercial	Industry	Category	Permission	TOKEN	Blockchain Platform	DETAILS	Link
The Hyperledger Healthcare Working Group	Commercial	Public Sector	Health Care	yes		Hyperledger	The HLHC Working Group already includes participants from organizations including Accenture, Gem, Hashed Health, Kaiser Permanente and IBM. The power of Open Source is the power of collaborative ideas. The Hyperledger Healthcare Working Group enables Healthcare enterprises, providers and users to focus resources on a scalable open source project to leverage collaboration	https://www.hyperledger.org/blog/2016/10/03/hyperledger-announces-the-hyperledger-healthcare-working-group
MyHealthMyData	Government	Public Sector	Health Care	yes			MyHealthMyData will create a platform relying on the blockchain system, a digital ledger where data transactions are visible to the entire network of stakeholders, minimizing any possibility of fraudulent usage. A dynamic consent interface will allow users to grant, deny or revoke consent to data access for different uses according to their preferences. The project will explore the feasibility of applications leveraging the value of large clinical datasets, particularly advanced data analytics, medical annotation retrieval engines and patient-specific models for physiological prediction.	https://ec.europa.eu/digital-single-market/en/news/blockchain-enable-medical-data-be-stored-and-transmitted-safely-and-effectively
Credits	Government	Public Sector	Peoples Data	yes		Credits	Credits is a public, high-speed, fully decentralized blockchain platform with Turing-complete smart contracts. Fintech startup Credits is what's known as a platform as service (PaaS), providing technology on top of which other companies and organisations can build apps. UK government has embraced the potential of blockchain, the technology which underpins bitcoin but which has far wider applications for recording transactions.	https://credits.com/en/Home/index https://www.cityam.com/uk-government-now-has-its-first-official-blockchain/
Smart Dubai	Government / Commercial	Public Sector					The Dubai Blockchain Strategy will help Dubai achieve the vision of being the first city fully powered by Blockchain by 2020 and make Dubai the happiest city on earth. The Dubai Blockchain strategy will usher in economic opportunity for all sectors in the city, and cement Dubai's reputation as a global technology leader, in line with Smart Dubai's mandate to become global leader in the smart economy, fuelling entrepreneurship and global competitiveness.	https://www.smartdubai.ae/initiatives/blockchain

PROJECT	Government / Commercial	Industry	Category	Permission	TOKEN	Blockchain Platform	DETAILS	Link
FACTOM	Government / Commercial	Public Sector		no	yes	Factom	The Factom® Protocol is a blockchain trusted by the U.S Department of Homeland Security, the Bill and Melinda Gates Foundation and other leading enterprise. The technology provides high throughput and easy integration into legacy systems, without the need to handle cryptocurrency. The protocol allows fixed costs to accurately budget projects, whilst securing unlimited data via simple API integrations	https://www.factom.com/
Bitnation Pangea	Government	Public Sector	Legal services		yes	Ethereum	Bitnation is the world's first Decentralised Borderless Voluntary Nation. Bitnation started in July 2014 and hosted the world's first blockchain marriage, birth certificate, refugee emergency ID, World Citizenship, DBVN Constitution and more. The website proof-of-concept, including the blockchain ID and Public Notary, is used by tens of thousands of Bitnation Citizens and Embassies around the world. Bitnation is the winner of UNESCO's Netexplo Award 2017,	https://tse.bitnation.co/
GovCoin	Government	Economy	Payments		yes		The UK government has quietly been testing out blockchain technology to make benefit payments. The department of work and pensions (DWP) has worked with Barclays, Npower, University College London and a UK-based distributed ledger platform startup called GovCoin to create an app which tracks spending. Claimants are using an app on their phones through which they are receiving and spending their benefit payments. With their consent, their transactions are being recorded on a distributed ledger to support their financial management.	https://www.cityam.com/government-has-quietly-been-testing-blockchain-technology/
Euroclear and itBit.	Commercial	economy	settlemen gold market			bitcoin	On June 21, 2016, Euroclear and itBit announced a collaboration to explore opportunities in creating a new settlement service for the London gold market using ItBit's proprietary blockchain infrastructure technology and flagship product, Bankchain. In December 2016, Paxos and Euroclear announced that they had completed a test of 600 gold bullion trades on Bankchain, the blockchain-based post-trade platform, with a group of banks that included, among others, Scotiabank, Citibank and Societe Generale. In late July 2017, however, Euroclear and Paxos announced the end of their pursuit of a joint precious metals settlement platform.	http://www.marketswiki.com/wiki/Paxos
IBM and Crédit Mutuel Arkéa	Commercial	Banking	KYC	yes		IBM blockchain	With help from IBM, Crédit Mutuel Arkéa used IBM Blockchain technology to create a functional pilot project that centralizes KYC information. The blockchain solution links the various systems of record, tracking the audit trail for each document from the moment the bank collects it	https://www.ibm.com/case-studies/e829728o57617x05

PROJECT	Government / Commercial	Industry	Category	Permission	TOKEN	Blockchain Platform	DETAILS	Link
Vchain Tech	Commercial	Transportation	Digital Identity			Stellar	To build so called 'SaaS' in the area of digital identity to help airlines share data safely and securely when passengers take connecting flights. The solution is designed to streamline airport processes and the work is aligned to the IATA One Identity vision.	https://www.vchain.tech/
SecureKey	Government / Commercial	Public Sector	Digital Identity	yes		IBM blockchain	SecureKey is a leading identity and uthentication provider that simplifies consumer access to online services and applications. SecureKey's next generation privacy-enhancing services enable consumers to conveniently and privately assert identity information using trusted providers, such as banks, telcos and governments, helping them connect to critical online services with a digital credential they already have and trust, while ensuring that information is only ever shared with explicit user consent. ecureKey Technologies and IBM are working together to build the first ever digital identity network in Canada.	https://securekey.com/
B3i	Commercial	Insurance					B3i Services AG was incorporated in 2018 and is 100% owned by 17 insurance market participants around the world. Our vision is to see a variety of applications for our clients to use which will help to reduce friction across the value chain and also improve the quality of data which the market is so reliant on. Our first application is for the Reinsurance market in the form of a Catastrophe Excess of Loss product. This product will be available to the market on our platform for the January 2020 renewal season.	https://b3i.tech/all-news.html
IBM Watson Health & US Food and Drug Administration	Government	Health care	Health Records	yes		IBM blockchain	IBM Watson Health in 2017 has signed a research initiative with the U.S. Food and Drug Administration aimed at defining a secure, efficient and scalable exchange of health data using blockchain technology. IBM and the FDA will explore the exchange of owner mediated data from several sources, such as Electronic Medical Records, clinical trials, genomic data, and health data from mobile devices, wearables and the "Internet of Things." The initial focus will be on oncology-related data.	https://www-03.ibm.com/press/us/en/pressrelease/51394.wss

PROJECT	Government / Commercial	Industry	Category	Permission	TOKEN	Blockchain Platform	DETAILS	Link
Guardtime	Government / Commercial	Health care	Health Records	yes			Guardtime HSX bridges the gap between patients, providers, payers, regulators and pharma by seamlessly transporting data across multiple healthcare stakeholders, delivering secure use of a single, truthful version of health data. Guardtime, the first and only platform for ensuring the integrity of data and systems at industrial scale, announced a partnership with the Estonian e-Health Authority to accelerate adoption of blockchain based transparency and auditability the lifecycle management for patient health care records.	https://guardtime.com/blog/estonian-ehealth-partners-guardtime-blockchain-based-transparency https://guardtime.com/health
Stampery	Government	Public Sector	Digital Identity	yes		Stampery BTA	The Republic of Estonia is the first country to offer e-Residency — a transnational digital identity available to anyone in the world interested in administering a location-independent business online. e-Residency additionally enables secure and convenient digital services that facilitate credibility and trust online.	https://stampery.com/estonia
Batavia	Commercial	Banking	Trade Banking	yes	no	IBM blockchain	A partnership between IBM and five banks (UBS, Bank of Montreal (BMO), CaixaBank, Commerzbank and Erste Group). Its aim is to create a cross border network which will be open to organizations around the world. The first live pilot transactions were successfully completed. Cars were traded from Germany to Spain and raw textiles for furniture production were traded from Austria to Spain.	https://www.ibm.com/blogs/blockchain/2018/04/blockchain-based-batavia-platform-set-to-rewire-global-trade-finance/
We.Trade	Commercial	Banking	Trade Banking	yes	no	IBM blockchain	A blockchain based trade platform that enhances the overall customer experience when trading internationally. Including newly joined UBS, Erste Group and Caixa Bank, 12 banks are now using we.trade. Already on board were Deutsche Bank, HSBC, KBC, Natixis, Nordea, Robobank, Santander, Société Générale, Eurobank and UniCredit. Thanks to the greater combined reach of the group, the platform will now be offered to clients in 13 countries.	https://we-trade.com/the-platform
Interbank Information Network (IIN)	Commercial	banking	Cross border payments		yes	Ethereum	Having launched as a pilot in 2017, J.P. Morgan's Interbank Information Network (IINSM) is the firm's first scalable, peer-to-peer network powered by blockchain technology. From minimizing friction in the cross-border payments process to enabling payments to reach beneficiaries faster and with fewer steps, IIN serves to address the longstanding challenges of interbank information–sharing. With an extensive network of banks 259, IIN continues to grow and evolve into a robust ecosystem.	https://www.jpmorgan.com/global/treasury-services/IIN

PROJECT	Government / Commercial	Industry	Category	Permission	TOKEN	Blockchain Platform	DETAILS	Link
WAX	Commercial	Entertainment	gaming	no	yes	Worldwide Asset eXchange	Is a worldwide asset exchange for video games virtual goods. The safest and most convenient way to create, buy, sell, and trade virtual items - to anyone, anywhere in the world.	https://wax.io/
Jasper (Bank of Canada)	Commercial	Banking	Payments	yes	no	Corda	Project Jasper was launched in March 2016 with the aim of understanding how distributed ledger technology (DLT) could transform the future of payments in Canada. The project represents a collaborative effort between Payments Canada, its member financial institutions, the Bank of Canada and other market participants.	https://www.payments.ca/industry-info/our-research/project-jasper
Ubin (Monetary Authority of Singapore)	Commercial	Banking	Settlement and Clearing	yes	no	Corda	Project Ubin is a collaborative project with the industry to explore the use of Distributed Ledger Technology (DLT) for clearing and settlement of payments and securities. MAS announced on 16 November 2016 that it is partnering R3, a Distributed Ledger Technology company, and a consortium of financial institutions on a proof-of-concept project to conduct inter-bank payments using Blockchain technology. The consortium includes Bank of America Merrill Lynch, Credit Suisse, DBS Bank, The Hongkong And Shanghai Banking Corporation Limited, J.P. Morgan, Mitsubishi UFJ Financial Group, OCBC Bank, R3, Singapore Exchange, UOB Bank, and BCS Information Systems	http://www.mas.gov.sg/Singapore-Financial-Centre/Smart-Financial-Centre/Project-Ubin.aspx
Funfair	Commercial	entertainment	gaming	no	yes	Ethereum	FunFair's goal is a world of truly fair, decentralised online gaming powered by blockchain technology. FunFair is a revolutionary blockchain technology platform that provides low cost, high quality, transparent casino experiences that are provably fair.	https://funfair.io/
Alianz - Nephila Capital Limited	Commercial	Insurance	Catastrophe swap	yes			June 15, 2016: Allianz and Nephila announce that they have successfully piloted the use of blockchain smart contract technology for transacting a natural catastrophe swap. The test run not only demonstrates that transactional processing and settlement between insurers and investors could be significantly accelerated and simplified by blockchain-based contracts, but also points to other benefits such as increased tradability of cat bonds and wider opportunities to apply this technology in other insurance transactions.	https://www.agcs.allianz.com/content/dam/onemarketing/agcs/agcs/press-releases/global/AGCS-Press-ART-Blockchain-pilot.pdf

PROJECT	Government / Commercial	Industry	Category	Permission	TOKEN	Blockchain Platform	DETAILS	Link
Alianz Risk Transfer	Commercial	Insurance	international transactions				Allianz has successfully implemented a blockchain prototype for an existing global captive insurance program of a client AGCS line of business. Allianz Risk Transfer cooperated with EY, Ginetta and Citi Treasury and Trade Solutions Prototype demonstrates that international insurance transactions can be significantly accelerated and simplified. Functionalities include cash payments, real-time access of tracked information and an intuitive, convenient user inter captive insurance platform with accelerated workflows for faster and more secure policy and claims management.	https://www.agcs.allianz.com/about-us/digital-transformation-and-insurance/blockchain.html
MediLedger	Commercial	Supply Chain Management	Pharmacy	no	yes	Ethereum	The MediLedger Project was launched by Chronicled in 2017. It brings together leading Pharmaceutical Manufacturers and Distributors using an advanced and customizable decentralized supply chain management system based on the principles of blockchain. This dynamic system innovates evolving solutions for track and trace regulations, and provides a step function improvement in the overall operation of the supply chain.	https://assets.chronicled.com/2017-MediLedger-Progress-Report.pdf
Modum	Commercial	Supply Chain Management	Pharmacy	no	yes	Ethereum	Modum.io offers a more efficient supply chain solution, which enables companies to prove compliance with GDP regulations using blockchain and Internet-of-Things (IoT) technology. The modum solution allows significant cost savings for the distribution of medicinal products that do not require active cooling. modum.io will offer its solution in a "pay-per-shipment" model.	https://www.modum.io/sites/default/files/documents/2019-05/white%20paper%20v.%201.0.pdf
Blodon	commercial	Health care	Blood donor	no	yes	Ethereum	BloodChain is the first Open Social Blood Bank. The Open Social Blood Bank concept is a metaphor that describes the BloodChain donors network available 24/7/365 to donate blood by required type, when and where is needed. All BloodChain community members together constitute the social blood bank. The community is open for all who want to support it, participate in it and use it.	https://blodon.com/blodon_bloodchain_white_paper.pdf
TradeLens	Commercial	Supply Chain Management	Shipping	yes	yes	Fabric	TradeLens, a Maersk and IBM solution formerly known as Global Trade Digitization (GTD), is a trade platform for containerized shipping, connecting the entire supply chain ecosystem. Ecosystems is comprised of over 100 diverse organizations including carriers, ports, terminal operators, 3PLs, and freight forwarders. It is also comprised of shippers from around the world. Together, participants publish and subscribe to data under a shipper determined digital permissioning model.	https://docs.tradelens.com/

PROJECT	Government / Commercial	Industry	Category	Permission	TOKEN	Blockchain Platform	DETAILS	Link
Mediachain	Commercial	Entertainment	Media	no	yes	ethereum	Mediachain is a peer-to-peer, decentralized database for sharing information across applications and organizations. It is a single port of entry for applications and users to publish, discover, and collaborate on media metadata. With Mediachain, a group of museums can collaborate on cultural heritage data in a shared system, a cooperative of openly-licensed image sharing platforms can publish attribution information to a community-maintained ledger, a consortium of music industry organizations can share rights data without ceding control to a third party, and a developer can build a decentralized blogging platform without needing to run a centralized database.	http://www.mediachain.io/
Inmusic	Commercial	Entertainment	music	yes	yes		Inmusik is a new kind of music streaming platform that aims to increase the entire economy of the music industry by incorporating game theory and blockchain. Our ecosystem enables participating fans to earn rewards by placing Token votes on content they believe will succeed over time and in turn, share in all future earnings. This approach introduces a new revenue stream for recorded music – something artists, labels and fans very much welcome.	https://inmusik.co/
Steemit	Commercial	Entertainment	Social media	no	yes	steem	Steemit is a blockchain-based blogging and social media website, which rewards its users with the cryptocurrency STEEM for publishing and curating content.	https://steemit.com/
DTUBE	Commercial	Entertainment	Video	no	yes	Steem	D.Tube is the first crypto-decentralized video platform, built on top of the STEEM Blockchain and the IPFS peer-to-peer network.	https://d.tube/
fnality	Commercial	Banking	Settlement and Clearing				The founding shareholders of Fnality comprise: Banco Santander, Bank of New York Mellon, Barclays, CIBC, Commerzbank, Credit Suisse, ING, KBC Group, Lloyds Banking Group, MUFG Group, Nasdaq, Sumitomo Mitsui Banking Corporation, State Street Bank & Trust, and UBS.	https://www.fnality.org/

PROJECT	Government / Commercial	Industry	Category	Permission	TOKEN	Blockchain Platform	DETAILS	Link
decode	Government / Commercial	public sector	Digital Identity	yes			DECODE is a project exploring and piloting new technologies that give people more control over how they store, manage and use personal data generated online. It will use blockchain technology to create tools that will give people ownership of the data which they and the devices they own generate, in order to respond to concerns about losing control of personal information on the internet. As a result the project will enable people to share their data with innovators, start-ups, NGOs, and local communities, who will have the opportunity to build apps and services to meet their needs.	https://decodeproject.eu/
Voltron	Commercial	Banking	Credit Leters	yes	no	R3 Corda	Founding members of Voltron include Bangkok Bank, BNP Paribas, CTBC Holding, HSBC, ING, NatWest, SEB and Standard Chartered. Voltron's initial aim is to use blockchain technology to bring significant efficiencies to transacting letters of credit.	https://www.r3.com/press-media/trade-finance-solution-voltron-launches-open-platform-on-corda-blockchain/
Komgo	Commercial	Banking	KYC	yes	yes	Ethereum	komgo is backed by 15 of the world's largest commodity trade and finance companies: ABN-AMRO, BNP Paribas, Credit Agricole, Citi, Gunvor, ING, Koch Supply & Trading, Macquarie, Mercuria, MUFG Bank, Natixis, Rabobank, SGS, Shell, Societe Generale. A private, shared blockchain network based on Enterprise Ethereum that serves as a secure, streamlined, and digital platform on which only authorized parties—banks, commodity traders, energy corporates, inspection companies and the broader ecosystem of participants—can store data, exchange transactions, and send messages more efficiently and securely based on permissions. This network enables the secure peer-to-peer exchange of documentary evidence to support Know-Your-Customer (KYC) due diligence and the execution of trade finance transactions.	https://komgo.io/
Uport	Government	Public Sector	Digital Identity	yes	yes	Ethereum	In September 2017, uPort launched the pilot of a self-sovereign identity platform, to be available to Zug residents. Using uPort's App, citizens can encrypt their personal information and receive an ID which is linked to a cryptographic address on the Ethereum blockchain. Once the information is verified, users can "seamlessly interact with the digital services of the City of Zug."	https://medium.com/uport/first-official-registration-of-a-zug-citizen-on-ethereum-3554b5c2c238

PROJECT	Government / Commercial	Industry	Category	Permission	TOKEN	Blockchain Platform	DETAILS	Link
Marko Polo	Commercial	Banking	Trade finance	yes	no	Corda	The initiative, called Marco Polo comprised of a group of the world's leading banks, together with trade finance technology specialist TradeIX and enterprise software firm R3, are piloting their trade finance solution leveraging distributed ledger technology following a successful proof-of-concept. Since launching in September 2017, with BNP, Commerzbank and ING as core banks, the initiative has attracted significant interest from the global banking community, with additional banks including Standard Chartered, DNB, and OP Financial Group joining in recent months.	www.marcopolo.finance