POLITECNICO DI MILANO

School of Industrial and Information Engineering

Master of Science in Management Engineering

The Impact of Blockchain and DLT Enterprise Tokens on Business Processes – Analysis of Applications of Different Use Cases in Major Industries

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Abstract

The term cryptocurrency is fairly generic and is sometimes interchanged with terms such as tokens, crypto money, or simply coin. These refer to digital assets that exist within a blockchain, but for different purposes. The primary purpose of a "coin" is to act as a medium of exchange or payment. The term "token" is used instead to identify a cryptocurrency that represents a particular resource (e.g., access to a service).

According to the European Banking Association, crypto assets are digital assets that utilize the Blockchain and more generally, Distributed Ledger Technology *as core part of their inherent value*. Such assets can be electronically exchanged in a peer-to-peer way, *neither issued nor guaranteed by a central authority*, and that are enabled by a network of computers running publicly accessible DLT software which applies cryptography.

Nonetheless, in such a dynamic fast-tokenized business environment, no standardized consensus has been achieved yet over their usage, rather only general guidelines. A wide plethora of crypto assets is deployed nowadays for extremely different purposes, which can take on different forms and characteristics, rendering terminology still quite fuzzy. In fact, you can generally leave it up to the context let define which category a particular cryptocurrency falls under.

After an initial introduction to the topic of tokens and the underlying technology, the research is divided into two main macro-sections.

The first part of this paper tries to wrap up widespread accepted classifications that have been adopted amongst academics in business literature so far in crypto assets to cement the foundations for a sounder methodology framework, bridging in the gaps.

In the last part, the results of a scholar research conducted in collaboration with the "Blockchain and Distributed Ledger Observatory" of Polytechnic of Milan on DLT-based token usages are advanced with the goal of investigating what motives are driving public and private corporations to employ digital assets as an integral part of their strategy, disrupting the current business processes.

Abstract (Italian)

Il termine criptovaluta è abbastanza generico e a volte viene scambiato con termini come token, "criptomoneta" o semplicemente moneta. Questi si riferiscono a beni digitali che esistono all'interno di una blockchain, ma per scopi diversi. Lo scopo primario di una "moneta" è quello di agire come mezzo di scambio o di pagamento. Il termine "token" è usato invece per identificare una criptovaluta che rappresenta una particolare risorsa (ad esempio, l'accesso a un servizio).

Secondo la European Banking Association, le criptovalute sono beni digitali che utilizzano la Blockchain e più in generale la Distributed Ledger Technology come parte centrale del loro valore intrinseco. Tali beni possono essere scambiati elettronicamente in modo peer-to-peer, non emessi né garantiti da un'autorità centrale, e che sono abilitati da una rete di computer che eseguono un software DLT accessibile al pubblico che applica la crittografia.

Tuttavia, in un ambiente commerciale così dinamico e veloce, non è stato ancora raggiunto un consenso standardizzato sul loro utilizzo, ma solo linee guida generali. Un'ampia pletora di criptovalute viene impiegata al giorno d'oggi per scopi estremamente diversi, che possono assumere diverse forme e caratteristiche, rendendo la terminologia ancora piuttosto confusa. Infatti, si può generalmente lasciare al contesto il compito di definire in quale categoria rientra una particolare criptovaluta.

Dopo una prima analisi iniziale per introdurre al tema dei token e della tecnologia sottostante, la ricerca si suddivide in due macrosezioni.

La prima parte di questo articolo cerca di raccogliere le classificazioni largamente accettate che sono state adottate finora tra gli accademici nella letteratura economica per cementare le basi di un quadro metodologico più solido, colmando le lacune.

Nell'ultima parte, i risultati di una ricerca condotta da uno studio sull'uso di token basati su DLT in collaborazione con l'Osservatorio Blockchain e Distributed Ledger del Politecnico di Milano sono avanzati con l'obiettivo di indagare quali motivazioni stanno spingendo le aziende pubbliche e private a impiegare asset digitali come parte integrante della loro strategia, sconvolgendo il modo in cui stanno facendo affari.

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Executive Summary

The World Economic Forum predicts that over the next ten years, 10% of the world's GDP will be stored in crypto assets (BitcoinMarketJournal, 2019). According to a new market research, fintech blockchain market alone is expected to grow at a 60% CAGR to reach $ 36 billion by 2028 (GobeNewswire, 2021).

Almost 7 years have passed from Buterin's yellow paper and from how we came to know the true potential of a decentralized, distributed computing power system, adding up to Nakatomo's pioneering contribution. Since them, crypto assets built upon a native blockchain have begun to rise at an unprecedented level. In jargon, "tokens" can be used to represent any wide range of scarce assets far beyond currencies (Chen, 2018).

Academics, industry experts and companies, both private and public, are leading studies to build solid knowledge that aims at fully detect and exploit the transformational opportunity given by new business models around crypto assets and blockchain. Annual funding to blockchain companies, more than doubled in 2020 compared to 2017 and annual spending on blockchain solutions will reach nearly $16 billion by 2023 (CBInsights, 2021).

Therefore, on the basis of these premises, the objective of this paper is to dispense insights on the state of the art of blockchain-based crypto assets by identifying ongoing applications in different sectors. In particular, we aim to contribute with a more practical understanding of how blockchain tokens work and how might disrupt the current way of doing business. Not just an alternative way of raising funds but a way to build new ecosystems.

Literature review and research questions

A review of scholarly research in the business literature on blockchain-based tokens has been conducted to investigate and analyze the eclectic landscape of crypto assets and eventually outline what have not been yet discussed, spotting future trends in tokens' adoption.

Technological aspects of the underlying technology have been thoroughly covered in literature (Freni et al., 2020) and overtime a fairly number of crypto assets' classification have been proposed as well, contributing to mapping legal and regulatory (FINMA, 2018; Lausen 2019), entrepreneurial and innovational (Chen, 2018), financial accounting (Yatsik, 2020), economical facets (AmaZix, 2019) or a blend of all the above (CryptoCompare, 2018; Olivera et al., 2018; Ballandies et al., 2018). Other academics' classifications are directed to fill in the notional gap with the current financial industry sector (Ankenbrand, 2020), as this is where most of investments are funneled and most of the applications domain operate, at least to date. In a plethora of crypto assets' types and contradictory

terminologies, there are also those - industry-driven organizations and practitioners such as EEA, Accenture, IBM, ConsenSys, R3, JP Morgan, … - who are joining maybes to develop a sound standardized framework to enable anyone from technlogists to businesspersons and regulators to have an holistic understanding of the phenomenon and take part in token projects (ITSA, 2020).

Despite this, empirical studies are very few and there is no research based on practical experience and real projects, just as there are limited studies that analyse crypto assets from a broader perspective and investigate how it affects the value creation. Hence, the ambition of this paper is to provide insights harnessing an empirical approach, aiming to fill the current gaps in the literature. Below are presented the research questions.

RQ1. Which are the sectors in which companies are employing tokens today?
RQ2. Which are the most impacted processes that follows the adoption of tokens in traditional private and public enterprises?
RQ3. Which types of digital assets are the most diffused into current companies' business model?

Research methodology

A census of all corporate and government projects that decided to dive into the realm of blockchain tokens has been produced not simply to answer the research questions arisen but to deep dive into the polyhedric meaning of crypto assets. The census was filled with blockchain initiatives coming from incumbents and established players – no startups - launched throughout the year 2021 (until October 4) and integrated with previous projects already censed by the Observatory of Blockchain and Distributed Ledger Technology and refitted under the current model, for a total of 151 initiatives overall. As sources to find the necessary information, the most reliable sites on blockchain and cryptocurrency were consulted, such as LedgerInsight, CoinDesk, CoinTelegraph and the Cryptonomist.

The framework adopted is thoroughly analyzed and explained in chapter 4. Nevertheless, the variables used are herein reported.
The variables used to classify the various projects stem from the experience of academics in literature and researchers of the Observatory from Polytechnic of Milan. One of the schemes followed for the current classification framework resides in the work developed by Olivera et al., 2018 inside the paper "*To Token or not to Token: Tools for Understanding Blockchain Tokens*", at the end of which eight different archetypes in terms of blockchain tokens' configurations have been drafted, to be eventually integrated with other archetypal tokens suggested by the census' findings.

The following archetypes have been drafted, according to the work of Olivera et al., 2018.

- Cryptocurrency. A token with the ambition to become a widespread digital form of currency.

- Equity Token. A token which confers to its holder a right to equity-related earnings, such as profit- sharing, application rents or platform fees.
- Funding Token. A token which is perceived as a long-term investment from the holder's perspective, and as a financing vehicle for the project's team and/or the community (bounties).
- Consensus Token. A token which is used as a reward to nodes which ensure data validation and consensus.
- Work Token. A token which is used as reward to users who complete certain actions or exhibit certain behaviour.
- Voting Token. A token which confers a voting right to its holder.
- Asset Token. A token which represents asset ownership.
- Payment Token. A token which is used as internal payment method in the application.
- Membership Token. Token that acts as an access-privileged pass for token holders. This archetype has been added as it was hardly stressed by the dataset.

Please note that a few precautions have been considered to exclude the possibility that incorrect and misleading information could impact the integrity of data.

- All the news about projects that failed has been removed from the census.
- For each project surveyed in the past, an analysis has been carried out to understand if changes in the development phases have occurred and if so, news were updated accordingly.
- If more news related to the same project were present, only the most recent one has been considered.

After having taken these steps, the overall number of cases has been narrowed down from 176 to 151.

Findings

Overall, the most impacted business process by the adoption of tokens, in principle related to the Payment sphere and to introduce an alternative, reliable mean of exchange, is being supplanted by other application domains, mainly related to Advertising management, covering incentive economies and fan engagement solutions mainly within the Art and Entertainment industry (examples of practical use cases are given by royalties tracking, advertising insights and original content creation) , and Capital markets, which exploit tokenization advantages to exchange financial digital securities, i.e, centralized and decentralized finance realm such as real-estate processing and cryptocurrency or other financial instruments exchanges for a minor part.

The current section aims at presenting the results obtained by the RQ3, as the one which best summarizes the whole thesis work. All the research questions will be addressed in the final chapter "Findings and Conclusion". A wrap up of the different archetypes is herein shown to assess the distribution and prevalence of the different tokens' typologies examined, highlighting the coexistence with more than one archetype at the

same time. In fact, these results suggest how the categories presented by Olivera are exhaustive, but somehow, intertwined with one another, underscoring the impossibility to categorize each digital asset within a single scheme or reference model. The outcome also displays the presence of potential "sub-archetypes", merged within the corresponding primary standard of belonging. Sub archetypes are indicated to the right of each frequency and account for approximately the percentage of the corresponding line. For instance, from the left, starting from the top, asset membership tokens accounts for little less than 1%, etc.…

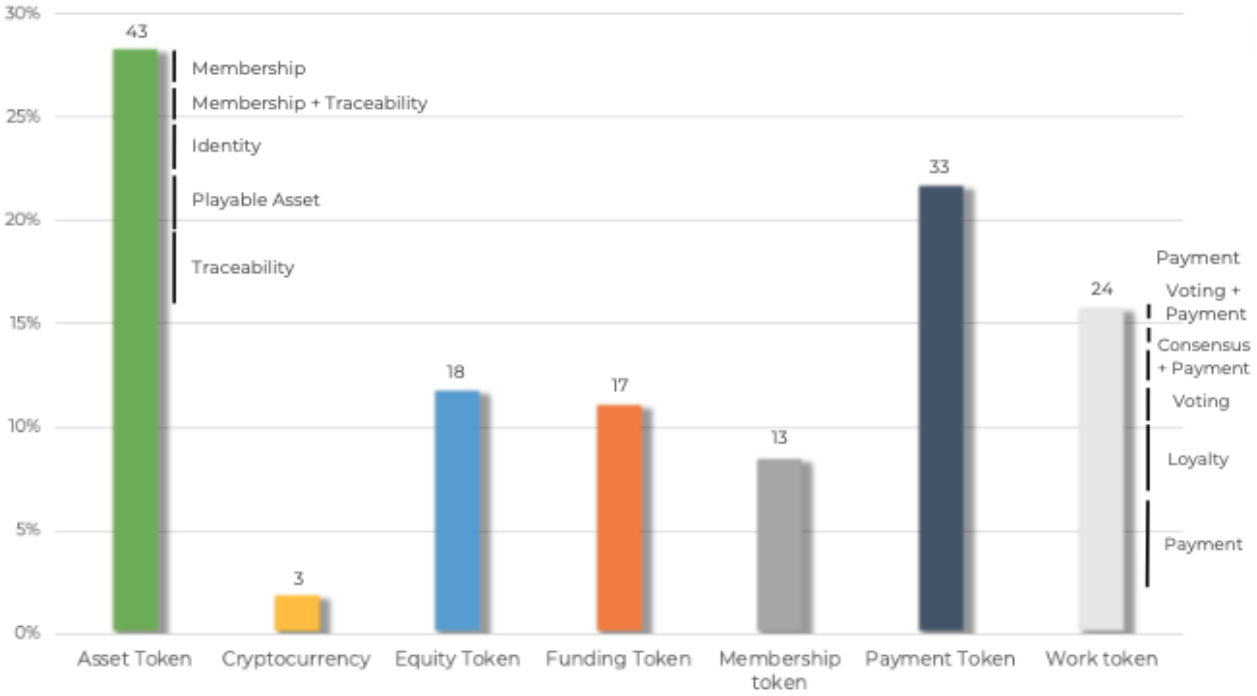

Chart 1 - Tokens' archetypes distribution. Sub archetypes are indicated to the right of each frequency and account for approximately the percentage of the corresponding line

The outcome of the research seems to substantiate the gradual pervasiveness in tokens' usage as a core element that triggers digital transformation process and foster innovation, shedding a light over disparate practical applications and how they help to make a business thrive. Whereas initiatives in such way seem to come mainly from private players, other actors like central banks and governments are a bit hesitant and seem to play for time as for how the whole technology adoption process will unfold. Public administration and local authorities are mainly using it for electronic voting, personal identity security and regulatory filings such as mortgage deeds and financial records.

By analyzing all the possible applications in business realm, the thesis has eventually deepened the results of previous literature as a new token archetype strongly stressed by the data that was not present in previous works emerged, that is the "Membership Token", a token that awards the holder with different incentives just by the simple fact of holding it. Not only in day-to-day applications, but such token configuration has also been meaningful in the DeFi and NFT wave that has begun to permeate from 2021 onward.

1 Blockchain Technology

The current paper does not explore in depth all the underlying aspects governing the functioning of the technology, as they are assumed to be taken for granted. Nonetheless, some concepts are elucidated just to the purposes of the analysis conducted.

1.1 What is a Blockchain?

Glaser definition, 2017. "*Blockchain is a transactional database, which is dis- tributed among nodes linked in a peer-to-peer (P2P) communication network. The access to the network is based on a permission mechanism, which enables the nodes to perform transactions that hold validity based on a consensus mechanism.*"

Our definition:

The blockchain is a digital, decentralized, distributed ledger on a network, structured as a chain of ledgers ("blocks") responsible for storing data, from valuable transactions to entire digital applications. It is possible to add new blocks of information but, on the other hand, it is not possible to modify or remove blocks previously added to the chain. In this ecosystem, cryptography and consensus protocols ensure security and immutability. The result is an open, neutral, trustworthy and secure system where the ability to use and trust the system does not depend on the intentions of any centralized entity or individual. A blockchain is architecturally decentralized, as there is no single point of failure there would be a need to turn off all nodes of which it is a part), it is characterized by decentralized authority, being that no authority has control over it, and it is logically centralized, being identified by a single - logical - state to function properly.

("The meaning of decentralization", V. Buterin)

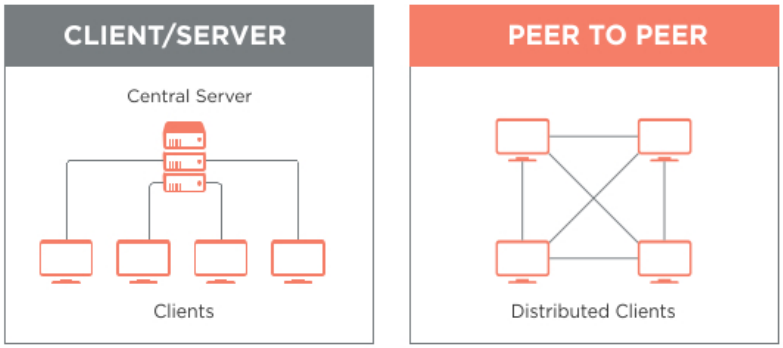

Figure I - Client/server vs peer-to-peer network

1.2 Database, Ledger and Blockchain

One of the main purposes of a blockchain is to store information of any kind, from an entire program to simple transactions. At the heart of the blockchain is the concept of recording transactions within a ledger, in the exact same way as a traditional ledger, an accounting ledger in which various categories of assets are recorded. Ledgers have been in use for many, many years, and an integral part of business processes since well before blockchain. While the concept has remained the same over time, the technology supporting it has evolved from paper ledgers to digital archives.

A distributed ledger is a shared database across multiple participants. Each party has a copy of the register and consensus might be achieved similarly to what happens in blockchain to maintain its state always up to date and synchronized. However, in a DLT data can be organized in numerous ways and do not need a specific sequence, differently from blockchain.

At a closer look, ledger and database may seem very similar, but while in the latter it is possible to insert, delete and modify data, in the former only the addition of information is allowed. It is possible to implement a ledger using traditional databases but imposing constraints on the operations that can be done. The blockchain grants several properties that go beyond the function of databases as simple "information repositories". At the same time, databases and blockchains fulfill different problems and it is unlikely that one will replace the other in the future. While a traditional database requires controlled access and is managed by known organizations or individuals, a blockchain is also used by unknown and untrusted parties without any form of access control.

In a blockchain, the digital ledger is structured as a chain of blocks, each responsible for storing information, be it transactions or programs.

1.3 Cryptoeconomy

A blockchain operates in an extremely adverse environment and to survive, they adopt a combination of cryptography, peer-to-peer networks, consensus protocols and economics, what we might call a "cryptoeconomics" approach. By combining cryptography and economic incentives, cryptoeconomics studies economic interaction in an adverse environment, where cheating is less convenient and more expensive than behaving honestly.

Assuming that most users are economically rational, it is possible to influence their behavior through economic incentives and punishments. Such incentives and disincentives compel therefore a rational user to behave in a determined way making possible to create trust between actors. In a blockchain it is not necessary to trust anybody, but thanks to these founding elements it can be ensured that transactions will be processed correctly, incentivizing users to cooperate according to the rules defined by the protocol.

Incentives for those who contribute to the creation of trust are monetary rewards and decision-making privileges (e.g., deciding which transactions can be included in a block). On the other hand, penalties for malicious parties involve economic losses (electricity in the PoW or cryptocurrency in the PoS) and loss of privileges (ability to verify transactions). Such concepts will be assessed later on in the analysis.

1.4.1 Cryptocurrencies properties

A cryptocurrency inherits all the properties of the blockchain on top of which it is developed. Depending on how the blockchain is designed, it is possible to build cryptocurrencies focused on speed, privacy, decentralization or any other feature. However, in blockchains as we came to know them until recently, since the introduction of Bitcoin, most cryptocurrencies share a common set of features.

- Digital. Cryptocurrencies only exist in digital form as units of account. No physical currency equivalent is present.

- Trustless. No need to trust a central person or institution to conduct transactions. Trust passes into the hands of a distributed consensus system.

- Secure. Ownership of cryptocurrencies can only be proven through cryptography. Since they are not associated with physical persons, but rather with addresses generated mathematically from a private key, accessing them to make transactions necessarily presupposes knowledge of the key.

- Consensus-based. The rules governing a cryptocurrency are programmed into the consensus mechanism that governs the decentralized network. The consensus, in addition to deciding the validity of a transaction, establishes its monetary policy.

- Neutral. A cryptocurrency does not discriminate based on the sender, recipient, or the object of the transaction.

- Global. They are not subject to any physical or political limits.

1.3 Hashing and cryptography

The connection between blocks in a blockchain is generated through a specific function called a hash, based on an indissoluble mathematical link.
The hash function is used to map data of arbitrary size to data of fixed size. A hash, regardless of what type of data is given as input, be it a pdf, spreadsheet or an entire blockchain, produces an output that will always possess the same number of bits. SHA-256 is currently one of the most common but also most secure hash functions used. A hash function:

- Is a one-way function, meaning that it is very easy to generate from any input, but having obtained the hash, it is very difficult to calculate backwards from the input. The only way to find the inverse function that allows you to do this is the brute-force method, but it forces you to try all possible combinations.
- The brute-force method is such that a slight modification of the input produces a drastic change in the output of the function. this means that if the starting file is altered in some way it follows that the relative hash will also change.
- The same input always produces the same output.

The hash function provides a very convenient and fast way to express the entire state of a blockchain through a string of precise length. For each new block generated, the hash of the previous block is inserted along with the data, transactions, of the current block to generate the hash of the new block. Consequently, adding, removing, or modifying information in any block would alter the hash of the block itself and all subsequent blocks, making tampering obvious.

Public key cryptography is a system that occupies a prominent place in many processes involving the blockchain. The generation of addresses and authentication of transactions occurs precisely from the combination of hashing and cryptography.
The basic idea is to use a mathematical key pair: a private key, randomly generated, that must remain secret and a corresponding public key that can be shared with anyone.
To represent a key, the hexadecimal representation is generally used in which the digits from 10 to 15 are represented by the letters "a-f".

In Bitcoin, the ECDSA algorithm based on elliptic curves is used to generate the keys. Specifically, the private key corresponds to a sequence of 256 ones and zeros. It follows that the largest number generated is 2^256, a number so large that it makes it nearly impossible to generate two identical private keys.

Exactly as with hashing, generating a public key from a private one is computationally very easy, but reversing it is not at all simple even with the current supercomputers out there.

The public key cryptography arises as a method of encryption to solve the problems of the symmetric one, i.e., the channel through which to transmit the key, the only one known by both participants, and the problem of authentication. With the symmetrical key method, anyone could generate a document and claim that it was created by the other party involved in the transaction.

Depending on the intended purpose, not all 4 keys - of the sender and receiver - involved in the communication need to be used. For example, if you want to ensure that a message is read only by the authorized parties, the sender only needs to encrypt the message with the public key of the recipient, who will use his private key, which is the only one he knows, to decrypt it. On the other hand, if, for example, the content is not important but you want to guarantee the identity of the sender, he will use his private key to encrypt it and the recipient will be able to verify the authenticity by decrypting it with his public key.

Unfortunately, an encrypted message that hides its contents from anyone not in possession of the private key can still be tampered with and modified without understanding what's inside. To overcome this problem, a combination of public key cryptography and hashing is used, which gives rise to the concept of digital signature. Like paper signatures, they are a way to prove someone's identity without their physical presence. Essentially, the digital signature is nothing more than a string of defined length that is created starting from the encryption of the digest, that is the output of a hash function, with the private key. In this way, the recipient simply decrypts the message and compares it with the hash obtained from the digital signature. The digital signature process is as follows.

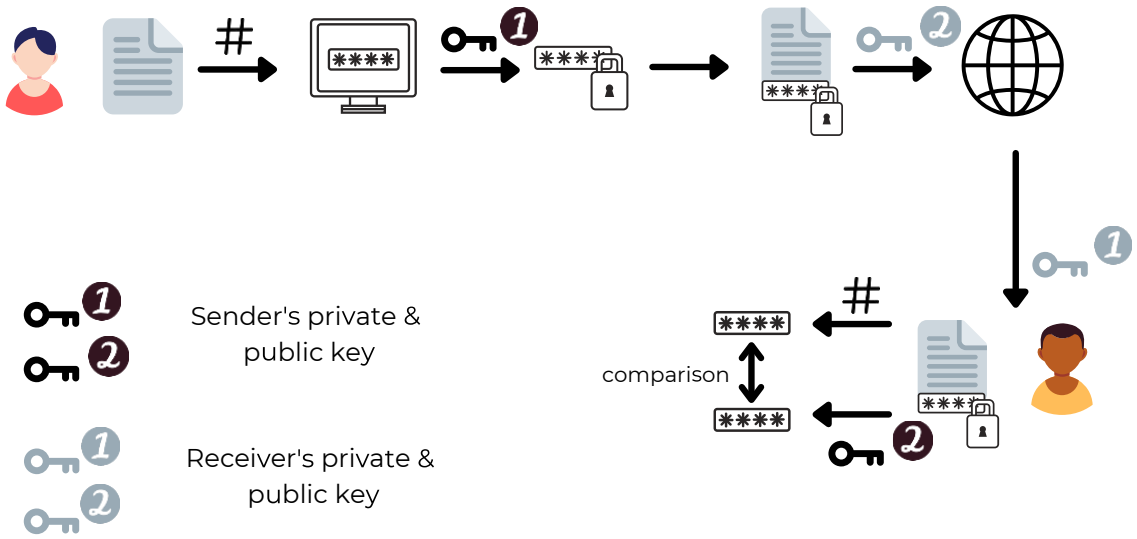

Figure II - Digital Signature Process

1.3.1 Advantages of asymmetric key encryption

The properties it guarantees are the following.

- Confidentiality. It guarantees that the data contained in a transaction is read only by the parties authorized to do so. if the information is sensitive and personal, it is referred to as "privacy".

- Integrity. Guarantees that the information is not altered by unauthorized parties.

- Non-repudiation. If someone signs a message, he cannot claim later that it was not him.

- Authentication. Connected to the previous one, thanks to the private key it guarantees unequivocally that the message has been sent by that user and his/her

identity verified. Authentication does not require knowing the user's genuine identity but requires providing information related to his identity, the private key.

1.4 Addresses

On a blockchain, there are no profiles, rather addresses. These do not contain cryptocurrencies but are identifiers of the destination of a transaction thus used for the transfer of digital assets.

Addresses in a blockchain are also generated in a process that involves both public key cryptography and hashing. First, the private key is created randomly, from this the public key is mathematically derived and the latter is then passed through various hash functions and cryptographic algorithms to obtain an address on the blockchain. The purpose of the address is to enable transactions to and from unique users.

Examples of Ethereum and Bitcoin addresses:

- 0x7949635E2877ef8ca37B8526507AC214B0423Ebf (Ethereum)
- 1BESGDJuEdevEn2rmLNaYMfojNksFjbE4Q (Bitcoin)

1.4.1 Wallets

Addresses are managed using wallets. A wallet is a piece of application (like a software) that runs on computers or mobile phones that communicates with the blockchain network as a node in the network.
A wallet, however, unlike traditional ones, stores the private and public keys associated with a particular address. In addition to determining the balance of all the addresses a user owns, wallets help automate functions such as authentication and signing transactions.
Depending on the environment in which they operate, a distinction can be made between cold wallet (hardware) and hot wallet (software).

1.4.2 Transactions

A valid transaction implies a change in the state of the blockchain. Since a blockchain is logically centralized, there must be only one state that is recognized by the network members. Consequently, the consensus for deciding which transactions have occurred and in what order is the only source of truth for determining the correct state of the blockchain. Whenever a user wants to initiate a transaction, he needs to prove that he owns the object to exchange and the only way to do this is through digital signature that allows to guarantee the properties mentioned above. Of course, there is no physical exchange but what a transaction does is nothing more than updating the amount that is transferred from the sender to the recipient on the blockchain ledger.

Each transaction is a deterministic and atomic transaction, in the sense of discrete, i.e., no intermediate state is passed. If the transaction is valid it is added to the block and contributes to changing the state of the blockchain, while if it is invalid the blockchain remains in its current state. The number of confirmations of a transaction corresponds to the number of blocks following the one in which the transaction itself is included. Although every successful transaction is considered immutable, in practice this cannot be said for a transaction that has received a single confirmation. In Bitcoin for example, it is advisable to wait about 1 hour - or 6 confirmations - while in Ethereum at least 3 minutes - or 12 confirmations -.

1.5 Blockchain typologies

There are different types of blockchain configurations with different architectures and functionalities which can be split according to two main variables: validation and access rights. The former concerns to whom oversees the validation of the transactions and creation of the blocks which brings to the first categorization between permissioned and permissionless blockchains. In these latters, anyone can download it and participate in the transaction process validation with no restrictions. Permissioned blockchain goes through a central organization which states which (known) identities are allowed to process transactions and add blocks to the chain.

Access rights instead refer to who can access and read the data. Therefore, this variable leads to the second classification between private and public blockchains. In public blockchains anybody can get access to data and submit transactions upon the network to be authorized and included in the current block. On the other hand, private blockchains limit access and the consequently opportunity to submit transactions only to restricted list of endorsed participants. This variable focuses on the confidentiality aspect discussed above when talking about cryptography by which only pre-defined users can query transactions.

By combining the 2 above variables, 4 main blockchain typologies can be obtained according to the ISO/TC 307 Blockchain and Distributed Ledger Technologies Standard:

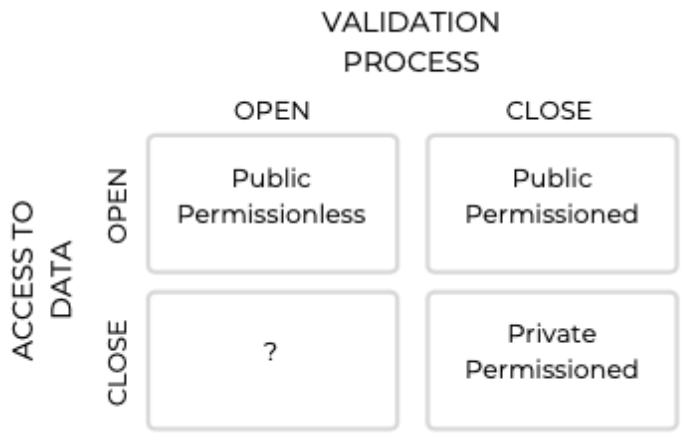

Figure III - Types of Blockchain

- Public Permissionless. Every node can take part in the validation and read through the history of the transactions. Each node has the same rights and responsibilities and there is no authority. The consensus algorithm is open-source and anybody can download it to check for inconsistencies or propose improvements. Bitcoin, Ethereum and Litecoin are few examples.

- Public Permissioned. The information and data are accessible and visible, anybody is eligible to submit transactions access as long as complying with the access rules, pseudo anonymity is guaranteed but only a few elected nodes can participate in the consensus mechanisms and are granted privileged unavailable to the public. They can control the activities performed by participants by assigning tailored roles and responsibilities. Sovrin, Ripple and EOS are few examples.

- Private Permissioned. Spread in industrial sector where companies along the value chain collaborate with one another, they sacrifice complete decentralization in exchange of access control and better performances. The authority/(ies) in charge of supervising the network have the duty to decide who can read and override data by participanting in the consensus mechanism. They can be either completely private if the authority is just one or consortium if control is distributed amongst the participants of the network. Both models can be convenient when an autonomous collaboration regime is to be established between different companies, or when sensitive data must be kept confidential. Examples are Hyperledger Fabric and Ethereum for Enterprise Alliance.

- Private Permissionless. In principle, private permissionless blockchain does not make much sense since it sounds like a contradiction. Anybody can spin up a node and become a validator but differently from a public blockchain, other nodes won't share their information with them. Since the blockchain is permissionless, privileges are assigned based on organizations identities. Each node is eligible to run ad-hoc chains and carry only the amount of data strictly needed to serve its users. Examples are LTO networks and Holochain.

1.6 Consensus mechanism

When we connect several computers together, the uncertainty of the whole system increases accordingly. They can crash, get hacked, and it is generally not possible to determine how the various connected software (nodes) will behave. Despite the uncertainty, nodes must always come to an agreement about what happened and that holds the only truth about the single current state of a blockchain. This process, called mining, takes place continuously and involves two main actors: full-node and miner.

1.6.1 Full node and light node

A full-node downloads and stores a copy of the blockchain locally and checks that the rules of the system are being followed. It is independent of others and does not need to place trust in any other node on the network. It will propagate blocks containing valid transactions and reject a block with anomalies, even if deemed valid by other participants. It is obvious that operating as a full node is quite inconvenient, requiring hundreds of gigabytes of memory. Full nodes are the key infrastructural components in the backend.
The average user who uses the blockchain instead operates as a light-node, in the sense that he receives only the data he needs from a full-node, delegating the trust but at the same time having a greater ease of use. Any wallet on a mobile device is an example of a light-node.

1.6.2 Mining

Mining is a decentralized mechanism that allows the network to validate transactions, group them into blocks and add them to the chain. Miners choose the transactions to be approved, sort and aggregate them into a block, and, along with full nodes, are responsible for verifying that the transactions and thus the blocks are valid so as to propagate them to the rest of the network. A full node then contributes to the security of the blockchain by checking the validity of each transaction and block to ensure that miners do not cheat. Only when a block is accepted by nodes and added to the blockchain are miners entitled to a reward that generally consists of transaction fees plus newly created cryptocurrencies.

Since each block has a limited size and can contain up to a maximum number of transactions, the miner will always tend to give priority to transactions with higher fees. As transactions are validated, they are placed in a transaction pool waiting to be added to the block. These are valid but not yet confirmed transactions. At this point a miner chooses the transactions and groups them into a block called a "candidate", which once created must be transmitted to the various nodes for validation.

1.6.3 Proof of Work

Proof-of-Work is one of the pioneer protocols used to achieve distributed consensus where voting power is based on computational power. The nodes in the network compete to solve a mathematically complex problem through a random process where the only way to find a valid solution is to try all possible combinations. The miner who can find the solution first has the right to create the next block, transmit it to the nodes of the network that verify the correctness and win the reward (Yuen C., 2020). As in hashing, it is a very complex problem to find but very easy for others to verify once

solved. When we talk about computational power, we refer to hash rate as the number of hashes computed per second. The probability of a miner to find a solution to PoW is given by the ratio of the hash rate of the pest to the total hash rate of the network, i.e., the sum of all the hashes of the miners. At each possible invalid combination in solving the math problem, the miner changes the value of a number called "nonce" that is added to the PoW input. This value is changed until the hash that is output satisfies a specific difficulty value. As the name suggests, this value indicates how difficult it is to find a valid PoW. The difficulty is updated periodically in relation to the network hash rate so as to keep the time required to generate a block as constant as possible. In bitcoin for example the difficulty is adjusted every 2016 blocks based on the average time it took to find the previous 2016 blocks.

Thanks to the hash function, if a malicious user attempted to tamper with a block, they would have to recalculate the entire PoW for all the blocks that follow up to the current one before other miners mined the next block. The further back one goes, the less likely an attack is to succeed – that is also why it is suggested to wait more than a single confirmation to ensure that a transaction will not be modified-. For this reason, the advantage of the protocol lies in the strong guarantee of immutability. Nonetheless, many are the disadvantages connected to the PoW:

- Massive energy consumption. Bitcoin, the quintessential PoW-based project, as of May 2021 recorded an annualized consumption of 151 TWh, consuming more energy than a country like Argentina, which has about 45 million inhabitants (Wall Street Journal). Also having more than 65% of mining activity take place in China, which takes electricity from fossil fuels, it is almost immediate how this contributes to significantly increased CO_2 emissions. However, it is exactly the enormous amount of computation required to validate blocks that ensures its immutability.

- Poorly scalable. The PoW protocol is also one of the biggest impediments to scaling the system, and many believe how such a small number of transactions that can be handled are blocking mass adoption. However, there are alternative solutions on layer-2 and off-chain that allow for easier scaling without abandoning the consensus algorithm. Off-chain payment channels enable are specifically designed to allow users to transfer money to each other without the need to immediately write each transaction to the blockchain but at the same time ensuring immutability and security. This allows you to minimize "clogging" of the network. One of the first ever introduced was the “Lighting Network” as a layer-2 solution for the Bitcoin network.

- Vulnerable to 51% attack. If a miner reached 51% of the network's computing power, it would be able to create blocks faster than all other miners combined. In such a case, while extremely unlikely, the miner in question could alter and reverse some of its own transactions - double spending - or block other miners from confirming new transactions - monopoly. However, even if a miner were to successfully execute such an attack, it would not be able to modify old transactions as it would have to calculate the PoW of all subsequent blocks while

honest miners would continue to mine on the correct blockchain. Such an attack, for Bitcoin, would require a very high amount of resources. despite this, for smaller blockchains that do not require such a high hash rate, such an attack is in feasible and has already been executed several times. Vercoin (2018), Ethereum Classic (2019) and Bitcoin Cash (2019) represent few examples.

1.6.4 Proof of Stake

Proof of Stake is another protocol for achieving distributed consensus but unlike PoW, validators (i.e., the equivalent of miners) are alternated and chosen in advance based on the amount of native cryptocurrency in their possession, the so-called "stake." Users can in fact stake their tokens, i.e., staking, temporarily blocking them, to get in return the right to confirm the transactions of a block, acquiring the role of validator, and unlock the reward. The parameters that are generally taken into account by the algorithm are the number of tokens staked and how long the validator has been in possession of those tokens. The voting power is calculated as a percentage of the tokens owned compared to the total stake in the network. There are economic disincentives for miners who abuse their voting power that include burning their staked coins. PoS is much more energy efficient and economical as there is no need to buy expensive hardware to do all those complex PoW calculations. All people can more easily participate in the network, also reducing the centralization typical of PoW-based systems. Although simpler in principle, a 51% attack would be more expensive since as soon as someone tries to appropriate the majority of the currency in circulation, the market would react with an increase in the price of the token. And even if that were possible, the attack would cause trust in the blockchain to plummet and as a result, the value of the token would also plummet precipitously.

1.7 Scalability

Things are much more complicated than this as blockchain has enabled many ways to intertwine different protocols upon which applications are built and to primarily solve issues related to scalability. State channels, sidechains and nested blockchains are few examples of solutions that have almost necessary after both Bitcoin and Ethereum started to experience network clogging with exaggerated transaction fees.

1.7.1 IOTA

To overcome some of the problems of blockchain, such as the difficulty of scaling and high transaction costs, there have been attempts to reshape the underlying structure of the technology under the name DLT or Distributed Ledger Technologies. These stand for applications that still leverage the concept of distributed ledger but structuring it no longer as a blockchain. In fact, while blockchain can be categorized as a type of distributed ledger, the reverse is not true.

An example of DLT is IOTA with its ledger called Tangle. This is a data structure used as the basis for IOTA native currency that does not make use of a linear structure but a special type of architecture designed for adoption in the IoT environment. A tangle is a ledger architecture based on a direct acyclic graph called DAG (Directed Acyclic Graph), where each node is connected to the others via direct links, without the presence of loops. Therein, there is no concept of blocks or chains. The rule is that each user has to validate two randomly chosen transactions before they can execute one. As a result, each user is also a miner and takes part in the validation process, effectively eliminating any scalability constraints and resulting in a completely self-sustaining network. In fact, the more transactions are created, the more transactions are validated.

Working within the IoT market and not finding in the blockchain a suitable solution, IOTA decided to create this structure with the basic idea of making possible and fast machine2machine micro transactions between thousands of billions of "users".

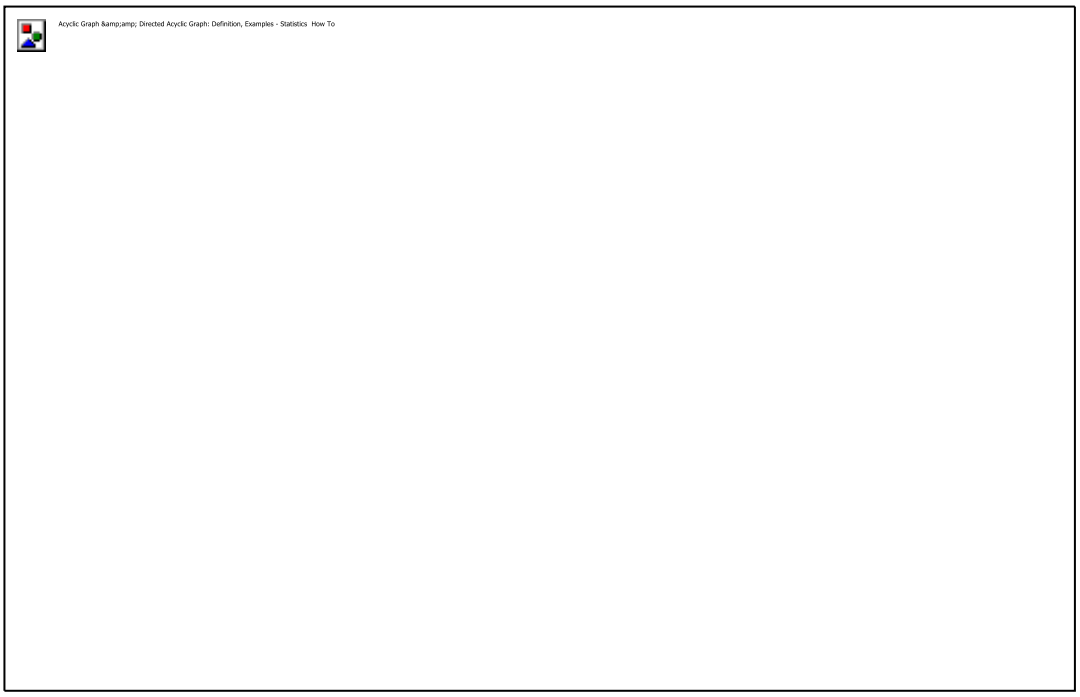

Figure IV - Directed Acyclic Graph

1.7.2 Layer-1 improvements

Scalability has been one of the hottest topics discussed in crypto realm. The scaling debate has heat up during periods of high network activity such as the CryptoKitties' hype in 2017, DeFi in 2020 or the crypto bull market at the beginning of 2021. CryptoKitties is a blockchain game on Ethereum developed by Canadian studio Dapper Labs that allows players to purchase, collect, breed and sell virtual cats. It is one of the earliest attempts to deploy blockchain technology for recreation and leisure.

During these periods the unmatched demand for Ethereum-related services resulted in extremely high gas fees making it expensive for everyday users to pay for their transactions. To tackle this problem the search for the ultimate scaling solution has been one of the top priorities for both developers and the Ethereum community.

In general, there are three main ways to scale a blockchain.

1. Scaling the blockchain itself. The idea is to improve the base protocol itself to make the overall system more scalable

Ethereum has embraced this direction through the gradual release of Ethereum 2.0 which is going to implements a mixed Proof-of-Stake and Proof-of-Work consensus algorithm and sharding, a concept already present in other fields – it was already used by Google's databases. The main hint is to divide the entire state of the blockchain in different independent smaller datasets, each with its own transaction history, called shards. Shards can then be processed in parallel by the network. Each node is assigned to process transactions inside few shards instead of the overall blocks, thus increasing considerably the efficiency.

1.7.3 Layer-2 scalability

2. Scaling building on top of layer one (main net) or layer-2 scaling. The idea is to create an overhead system architecture on top of the main layer that "borrow" its security features while taking charge of reducing the load the blockchain is subjected to.

The most well-known are Bitcoin's Lightning Network that allow participants to make transactions off-chain multiple times while recording the final balance on the blockchain at a later date when the channel is closed. Users who want to transact send the amount of money they want to trade and sign it over to a smart contract which returns the voucher and connects them to a state channel application. Fees are paid only to get in and once the channel is closed to update the blockchain. One of the strengths is that you don't have to open a direct channel - and then make a transaction on the blockchain - whenever you want to transfer money with someone. It would be possible for two participants to take advantage of the existence of an indirect path that connects them by leveraging the redirection potential of the network. In this way, it is also possible for the sender to choose which routes to use for example based on the speed or the cheapest rate. However, it is application specific- payment only- and does not support fancy contracts.

Ethereum Plasma is a layer-2 framework implemented for building scalable decentralized applications on the Ethereum network. It is an example of nested blockchains that leverage the use of smart contracts and merkle trees to enable the creation of an

unlimited number of child chains, these being miniature copies of the main chain to form a tree-like hierarchy structure composed of many "parent-child" connections. Offloading the work from the main chain into child chains allows for fast and cheap transactions. The system is general-purpose since each child chain is designed to serve different needs and operate independently from the others but drawbacks are related to a long waiting period for users who want to withdraw their funds from layer-2 (mass exit problem).

1.7.4 Sidechain

3. Building on the side of layer one - side chain. As the word itself suggests, it is adjacent to the main one via a bi-directional link and running in parallel.

They employ their own independent consensus mechanism; this means that the network could be more vulnerable to attacks and hacks if there isn't enough mining activity. Sidechains are usually EVM compatible, thus can scale also general-purpose application. However, important efforts are required for the infrastructure to be ground up from scratch.

Polygon (MATIC) is an example of sidechain for the Ethereum network and is becoming a sort of hatchery for many newborn projects. Polygon enhances the user experience on the blockchain by enabling instant and cheaper transactions while also being interoperable with other blockchain networks.

1.7.5 Rollups

Rollups are one of the main recent developments in terms of layer-2 scalability. Rollups are solutions that perform transaction execution outside the main Ethereum chain but post transaction data on layer 1 (Ethereum website definition). Thus, they wholly inherit security features from the Ethereum consensus performing execution outside of it. The main idea behind rollups is to wrap transactions up together in a single transaction to be then submitted in the smart contract to the main net, serving as a proof to the sidechain state. There are two types of rollups.

- Optimistic rollups. They assume that the data posted on the Ethereum main net is authentic. However, a dispute resolution system is put in place to detect fraudulent behaviors and disincentivize malicious actors from submitting deceptive transactions, all by harnessing the principles of game theory. The parties eligible to post transactions who wish to provide fraud proofs are in fact required to stake a bond in the rollup smart contract which will eventually be slashed if culprits get caught. Because of challenge and fraud proofs which require to reconstruct the sequence of transactions on the Ethereum blockchain, optimistic rollups might be burdensome when trying to withdraw funds.

  Nevertheless, many projects in the DeFi domain are planning to migrate to ORs or they have already done it thanks to the massive improvements in terms of

scalability offered (10 x – 100 x, data from Ethereum.org). Examples are Uniswap, Chainlink and Synthetix.

- Zero-Knowledge Rollups. Submit a validity proof to the chain by assuming that transactions executed on layer-2 are faulty. ZK rollups rely instead on cryptography and mathematics to solve disputes through the so called "zero-knowledge snark", a proof that can be easily verified by the rollup contract to spot any suspicious transactions right away. Withdrawals takes place as soon as transactions are presented with their correspondent proofs which make this type of rollups more efficient and secure. However, this process requires way more computation and resources - than its counterpart - that run on their own virtual machines, generally not EVM compatible. Another considerable handicap is the incapability to handle data in smart contracts as they can be used only to record simple transactions.

  Loopring, a decentralized exchange application, is an example of Z-K rollup solution. Hermez and ZKTube are other examples of protocols using ZK rollups to provide fast and high-performance payment and custodial services to end users.

2 Token

Without neglecting the importance of the underlying infrastructure and its features, a deep understanding of tokens' nature is preliminary condition to unleash the potential of blockchain technology.

Mougayar et al., 2016, define a token as a *"unit of value that an organization or private entity creates to govern its business model and give more power to its users to interact with its products or services while facilitating the distribution and sharing of benefits*". The definition pictures tokens as a socio-technological paradigm. In fact, tokens have both a technological element intended as a log in a blockchain database, and a social one – i.e., their purpose of usage amongst a group of people whose changes in relationship will influence its value over time upon a system of incentives and agreements defined by the network and following the logic of the issuer. However, the social aspect assumes in Freni's et al. work – 2020 - the meaning of trust. Tokens themselves do not possess any intrinsic value and it is what they stand for and the context in which they are dropped that shape it, provided that such group of people trusts the token issuer and its capability to honor the obligation associated with the right represented by the token. For example, the value of a token that is obtained to remunerate blocks validation reflects the level of trust that users assign to the overall ecosystem.

Tokens have been around us for a long time before being explicited with the advent of blockchain, and have always been associated to multiple types of economic value, from

the most ancient like pearls and shells used to replace money until the more recent ones and closest to our daily experience such as vouchers, gift cards, tickets, loyalty points, poker chips or any kind of certificate – stocks, bonds - asserting some kinds of right to the bearer. Let's think also of ID cards, club memberships, company badges and so on and so forth. Tokens have also been spread in information systems, from the most abstract - whenever a client-server connection was set up when surfing on the browser, that web itself would send tokens that allow users to accomplish some actions or to cope with access permissions – to the most tangible like bar codes and QR codes.

After Bitcoin, whose currency was embedded inside the software itself, the first-to-come crypto tokens – intended not as native coins - appearing in the blockchain domain were built as Bitcoin code plugins – see Dogecoin and Litecoin. Bitcoin itself was a non-Turing complete scripting language allowing just to transfer peer-to-peer value. With the implementation of Turing-complete environment – Ethereum's machine et sequential – it has become possible not just to attach - and decode - metadata to transactions but to have built-in executable programs able to solve complex logics and computational problems. In other terms, smart contracts enabled to create cryptocurrencies from the core protocol of the native blockchain – in jargon, tokens – whose utilities go far beyond simple transfer of value, rather than developing different software specifically designed to work with each operating system.

The disruptive potential mentioned at the beginning lays roots in the expansion of the concept of value beyond purely economic terms as we intend today to include also reputation, work, copyright, utility, voting rights, properties, and any proof of given behavior declined for each specific use case. Tokens meaning is strictly related to the concept of tokenization, which Freni et al., 2020 define as *the process of encapsulation of value in tradeable units of account.* Once tokenized into digital assets, all these *manifestations* of value can be recorded and capitalized within a framework of incentives and wealth redistribution through a virtual token which represents their unit of account.

2.1 Smart contract

The first time the term smart contract was proposed was in the paper of N. Szabo, dated 1994, who defines it as computerized transaction protocols that execute the terms of a contract, whose objective is to satisfy contractual conditions in a fully automatic way, minimizing malicious actions and counterparty risk, understood as trust in intermediaries.

While at that time the scope was related to electronic data exchange systems, today the concept of smart contracts has become celebrated in the context blockchain technology. These are just like contract as popularly known but managed on a distributed ledger - and written in a digital format -, the application of which is essential to create trust between the parties involved in a transaction. In fact, the idea behind them is to provide a system that goes hand in hand with blockchain inner properties, i.e., security, decentralization, transparency and tamper-resistance. A smart contract is defined as an automatically executable piece of code part of an agreement between non-trusted parties and once

stored across the nodes of a blockchain, it becomes immutable and cannot be updated. It can be seen as a combination of IFTTT conditions ("If This, Then That"), which means that if the parties have initiated a transaction and certain parameters governing the agreement have been met, the code will execute the steps triggered by those parameters. If no such transaction has been initiated, the code will not take any steps. Since human intervention is not required once a smart contract has been deployed, thereby sinking by far the implementation and enforcement costs of the contracting process.

However, smart contracts are not impervious. They might be subject to attacks if a flaw within their code is found and taken advantage by malicious actors like what happened in 2017 with the DAO attack. In the end, it might be argued that smart contracts are neither smart – they are dumb pieces of code – nor even contracts – their legal validity is still a matter of debate.

There are many platforms supporting smart contract executions besides Ethereum - i.e., layer-2 Bitcoin Lightning Network, Stellar, Hyperledger Fabric, … -, which since its launch has always been one step ahead. Smart contracts in Ethereum are written in Solidity, a high-level programming language that is compiled into machine language - low-level binary bytecode – and executed by and inside the Ethereum Virtual Machine, which can be thought as a virtual CPU that harness the computational power of the different nodes of the network. This was the real innovation that Buterin brought. The EVM is a distributed state machine that ensures that the same contract is executed in isolated environments and in the same way on each node of the blockchain. Each smart contract lives inside a specific address stored amongst all the nodes of the network and just like a normal wallet, it has a balance and an address. Nevertheless, while a normal account is controlled by the owner's private keys, accounts related to smart contracts are controlled by immutable code written inside them. This program written by developers and uploaded onto the blockchain automatically activates and is retrieved when its address is called through a transaction. Once a contract is solicited, it starts to execute the commands contained in it and potentially produce a change in the state of the blockchain, all of which is kept track inside the EVM.

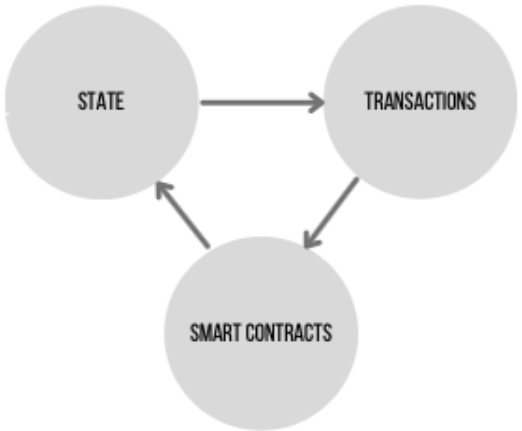

Figure V - Blockchain states' changes in the EVM. State is altered by transactions, which interact with smart contracts that in turn modify the state of the blockchain.

2.1.1 Oracles

Being executed in isolated environments, a smart contract could not interact with an external source of data that is not the blockchain, especially not to undermine the deterministic model by which results obtained from the execution of a contract must be unrelated to the node that processes it. If this were the case, it could happen that two nodes might receive different data or that the same node receives other data from those returned some time ago, inevitably affecting the verification process. To overcome this, oracles have been introduced. Albeit niche and still at embryonal stages, these are services specifically designed to connect a blockchain with the outside world by providing the blockchain with the information needed.

Oracles are used when smart contracts have to query external data source that they cannot access through the blockchain, such as weather information, sports results, stock quotes, exchange rates, etc.… Of course, these pieces of information must be reliable to take decisions as plenty of money is at stake.

This is not a one-way connection, as data can be extrapolated from a blockchain and send it to external applications, allowing individuals and businesses to safely access it.

Generally, blockchain is connected with multiple oracle networks running in parallel which are not interdependent one another and provide multiple services such as price feeds, proof of reserve, cross-chain interoperability protocol and off-chain computation.

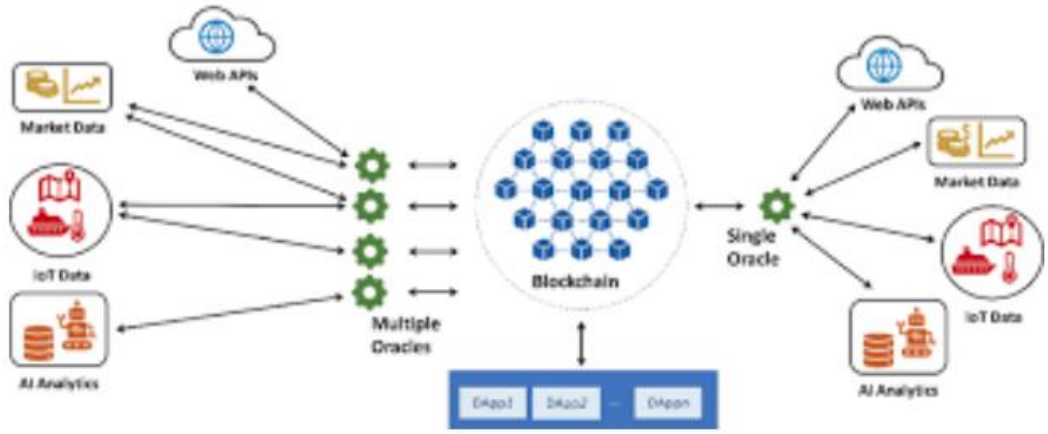

Figure VI - How Oracles work

2.1.2 Transaction fees - the Ethereum case

Ethereum is a versatile, neutral blockchain that can be programmed via smart contracts to fulfill different objectives. The idea of the founder Buterin was to build a blockchain, or "global computer", that could be used to run generic programs, smart contracts, in a continuous decentralized and uncensored manner. It is a public blockchain based on the same consensus algorithm as Bitcoin - i.e., Proof of Work, although the move to the more scalable Proof of Stake protocol Casper has been planned for some time and auspicated by many. Its own currency is ETH, unlike BTC it does not have a maximum quantity (deflationary), so the inflation rate is simply controlled by limiting the number of ETH entered.

The ETH token can be divided into wei, with the following ratio: 1 ETH = 10^18 wei = 10^9 Gwei. This unit of measurement is important when considering fees, known as "gas". Gas is a unit of measurement to determine the amount of computation required to perform an operation at the blockchain. It can be compared to the fuel consumed by a car during a commute. Any operation such as calculating a hash or transferring money requires a certain amount of gas. Since there is no token named "gas," this is a concept solely and exclusively related to transactions.

Transactions made on the network requires the payment of a fee which consists of two parameters that determine the cost that will be paid by users to have them verified by the nodes and added to the chain.

$$transaction\ cost = gas\ price \times gas\ limit$$

The gas price is the number of wei to be paid per unit of gas. Not being a token, as we mentioned earlier, the gas is paid for by the sender of the transaction in ETH and purchases it at the price specified in the transaction itself. Everyone is free to set the price they prefer but it must be kept in mind that miners are free to choose the transactions they want and therefore will give precedence to those that allow them higher profits. The gas limit is the maximum amount of gas that can be consumed in a transaction. Setting the gas limit in a transaction is crucial if you don't want to risk it vanishing before it reaches its destination and avoid losing all the gas. If, for example, a transaction requires 15 gas but we set a limit of only 10, execution will stop as soon as the limit is reached. If, on the other hand, we set a limit of more gas than is actually used by the transaction, the excess gas is returned to the sender.

The gas limit also has another important security function to prevent attacks or programming errors in contracts that could overload the network. Think of a poorly written contract, if it goes into an endless loop, the presence of a ceiling ensures that the execution of that contract will end when the available gas runs out.

2.2 Token standard – The Ethereum Request for Comment

ERC stands for Ethereum Request for Comment and is the standard that identify functionalities within a smart contract of the Ethereum blockchain, currently the most widely used. Depending on which functions holders are allowed to perform, different specific standards can be chosen. The most popular are the ERC-20 standard, which has become known thanks to ICOs, and ERC-721, for the creation of non-fungible tokens. The tokens created always take the name of the standard used to create them, that is why some confusion between terminologies may arise. Knowing these standards helps any programmer who wants to build for a given protocol to call the correct functions especially when writing one or more smart contracts communicating together to create decentralized applications, i.e., dApps.

Please note that this section provides the main standards for the Ethereum blockchain, but each proprietary blockchain that enables smart contracts programming has their own ones. For instance, the Binance Smart Chain uses, amongst the others, the BEP-20 which is the analogous to ERC-20 – besides little modification to improve the protocol – in Binance blockchain but completely interoperable with it.

2.2.1 Fungible token standards

These standards allow to create divisible, non-unique and interchangeable assets such that each fraction (unit) of it is equivalent to the other and therefore can be exchanged with other fungible asset of the same amount. The most intuitive example of fungible tokens is fiat money like dollars or EURO. A 10€ bill is interchangeable with any other 10€ bill and nobody cares if they are given back exactly that same bill because they are identical and the value will always remain the same, that is 10€. The only difference is that when it comes to cryptocurrencies, the fungibility property is expressed through a code script, i.e., smart contract.

2.2.1.1 ERC-20

From a technical perspective, a token contract is configured as a register of blockchain addresses – accounts - that have a certain quantity associated with them – balances -, along with a set of functions that users can "call" to manipulate that list, such as "transfer n tokens from address a to address b", and predetermined rules to decide who can perform actions with that list and in which way. What we call token is indeed the unit of a balance, which can represent any kind of value outlined by the creator, whether a software license, a monetary value or physical objects.

Holder address	Balance
0x0000...0000	0
0x1f59...3492	100
0x2299...3ab7	100
0x4ba5...ae22	100
0x4919...413d	100
0x93f1...1b09	100
0xd8f0...c028	100
0xe20b...93b6	100
Total supply	700

Figure VII - List of addresses and users' balance

The ERC20 is the most widely adopted standard in the blockchain industry. The ERC-20 standard is a smart contract defined by its contract's address that contains the following functions:

- *name*. it is the name of the token contract.
- *symbol*. Symbol by which the token is known, as an abbreviation using the initial for the name, generally much longer.
- *decimals*. They refer to the degree of divisibility a token value might be subject to, going from a minimum of 0 - no divisibility – to 18 or higher in some cases for almost continuous value range. They refer to the digits that follow the decimal point. Setting the most suitable number of decimals depends on the type of value tokens stand for. This function was introduced because Ethereum does not handle decimal numbers.
- *total supply*. Total quantity of existing tokens as the sum of all balances. It records minting – i.e., creation – of new tokens and burning – i.e., destruction.

Other functions are:

- *balance of*. Followed by the address, returns the number of tokens owned.
- *transfer*. Function that enables the transfer of tokens from an address, and so from the smart contract that created them, to another. However, this function does not work well when a user wants to interact with a smart contract to perform certain actions and operate it. It can be called only by the token holder.
- *transferFrom*. Enables the transfer of tokens from the account of one user to another but it's callable a smart contract – i.e., approved account. Followed by the holder's address, this function grants the smart contract to interact with the user's address.

- *approve*. Makes it possible to check a transaction against the number of existing tokens so that there are no missing tokens or more than there should be. Basically, when interacting with another contract, users are allowing them to validate and spend a given number of tokens they have in their wallets before any transfer or transaction may take place on behalf of them.
- *allowance*. Checks that a user has enough funds to make a transaction. With dApps, this function allows the smart contract to get access to and transfer the tokens allowed by the user.

Holder address	Allowance address	Allowance
0x1f59...3492	0x2299...3ab7	50
0x1f59...3492	0xd8f0...c028	25
0x2299...3ab7	0x4ba5...ae22	500
0x4ba5...ae22	0xd8f0...c028	10

Figure VIII - Token holders' allowances for transfers

In the above image, an example is reported. The first line indicates that the user address 0x1f59… 3492 has allowed the smart contract 0x2299… 3ab7 to transfer up to 50 tokens from the holder's account. The allowance may take place just at the beginning when firstly interact with the contract or on discretionary basis, according to how the smart contract is configured. However, allowances are "soft" security instruments as they can exceed any address's balance. Moreover, allowances addresses are publicly queryable.

The ERC-20 demarcates two types of events that are used to inform the calling application or another contract about its current state. Applications or other external programs operate according to the information that events deliver. As in any other programming language, in the EVM events are defined as *inheritable members of a contract, which store in the blockchain the arguments passed in the transaction logs when emitted (*Wikipedia*)*. Events are useful because it is possible to trace parameter changes with no need of querying the entire blockchain. In fact, as long as the contract lives on the blockchain, these changes are recorded inside blocks as transaction logs – i.e., history of changes to the database used to guarantee tamper-resistance and hardware failures – accessible through the contract address. The events are:

- *transfer*. Keep tracks of the details of the moving funds from an address to the other and is emitted when tokens are successfully transferred.
- *approval*. Releases tokens' approval details from an address to another when tokens are successfully approved.

For instance, the act of mining new tokens in the contract – i.e, increasing its total supply – gives rise to a "transfer" that has 0 as the source address – i.e., log. However, when tokens are burned – so when the total supply gets reduced – no event is showed. Since tokens can be burnt in two ways, either by reducing existing tokens or by forwarding

them to a smart contract that does not possess any private key (the "0" address), the latter way is privileged using the transfer to the zero address so that a trace is output.

2.2.1.2 ERC-223

The ERC-223 is an Ethereum Improvement Proposal standard designed to preserves all the functionalities and utilities of ERC-20. However, it was born to fix or better enhance some problematics that systematically affected the ERC-20 smart contracts. The main shortcoming was related to the irretrievability of tokens once they would be forwarded mistakenly when interacting with other type of smart contracts. In fact, the ERC-20 smart contract was designed to make users perform transactions just amongst themselves, so that these tokens could be sent only to other owners' accounts. Accidentally, when a consignor calls the "transfer function" and the receiving address is improperly typed or corresponds to a contract that do not explicitly support token receiving, he will never be able to realize it because from his side the sender will see that the transaction worked out successfully but actually the tokens dispatched are lost. Basically, the tokens sent get stuck in that contract's balance since the recipient dispose of no means to transfer these tokens to other accounts and no mechanism is in place to prevent this from happening. According to CoinMarketcap, this flaw – found out by an Ethereum developer - has cost users more than $ 3 million dollars.

The improvements introduced are the followings:

- anytime a user wants to send tokens he should always be calling the transfer function, the contract checks whether the receiving address is a contract account or a normal wallet address. If by looking at the byte length of the contract – 0 for normal addresses and > 0 otherwise, checked thorugh an assembly function of the code - it discovers that the recipient is a contract, the smart contract will – must - assume that a token "*Fallback*" function is implemented in the receiver's to handle this. Thus, if any error occurs when calling the fallback function or this function is not implemented in the recipient's contract, the amount sent is returned to the user so that funds won't be lost. The fallback function already existed for the ETH currency whenever users would send their funds to a contract not planned to work with Ethereum with the aim to return and refund the ETH sent by accident.
- the *transferFrom*, or delegated transfer function, is taken away since it is not needed due to the presence of the fallback function.
- a new function named *tokenReceived* is implemented and must be executed to handle incoming tokens.

The ERC-223 triggers two different events when are interacted with:

- *transfer*. Keep tracks of the details of funds movement, backward compatible with the ERC-20 transfer event.
- *transferData*. It logs transactions metadata.

2.2.1.3 ERC-1400

The ERC 1400 is the security token standard introduced by Polymath members in 2018 to handle the exchange of financial securities, which by nature are instruments that could not be programmed using the ERC-20 token standard and serves to manage more complicated things like corporate actions, i.e., dividends distribution, or seizure of assets. This library is composed of the following standards – all backward ERC20 compatible -, namely:

- ERC1594. Like the ERC-20, it defines the basic core rules on how tokens are created (i.e., *issue*) and burned (i.e., *redeem*). The *transfer* and *transferFrom* are basically the same of the ERC20 with the only difference that data fetched off-chain through oracles can optionally be attached to them (for instance, command to get the price of a share from an exchange or the volatility for that stock) to enable transfers only when certain conditions are met. Nevertheless, when transacting with securities a variety of reason may arise hindering them to be transferred such as vesting periods, KYC being not approved yet, non-accredited investor, citizenship or for other reasons set at the contract level, i.e., a cap on the maximum amount an investor can hold. As the causes for stoppages get more complicated, two more functions named *canTransfer* and *canTransferFrom* are included to decide whether a transfer can take place prior to its execution.

- ERC1410. It enables to derive tokens partition, assigning them distinct metadata, even if in principle they refer to an identical underlying asset. For instance, it might be the case of a company issuing preferred and common stocks, in this way two partitions are created and attached to different rights, duties and restrictions in the form of metadata. Likewise, during a security lifecycle, a partition might be necessary to split holders' balances to separate tokens issued in the primary market to those obtained during secondary trading, with the correspondent restrictions. Partitions can be created and destroyed – i.e., redeemed - exactly like tokens. Tokens can also be transferred by partitions through the function of the same name.

- ERC1643. This standard, called Document Management, is used as a linkage between the tokens running on-chain and the corresponding legal documents stored off-chain so that an investor – token holder - can always be informed about changes, retrieve documents at any time, attach new documents or update its location on the Web – URI -, remove an existing document from the contract or retrieve the full list of documents. Contents of these documents can be hashed on-chain to guarantee tamper-proofness.

- ERC1644. Like in real-world application, securities issuance and trading involve many actors intervening at different steps of the value chain. For instance, a regulatory entity might want to oversee what's happening and if deemed

necessary, seize the tokenized stocks of a particular individual due to issues with creditors' shareholders. In principle, the smart contract issuer reserves this control to himself but usually it delegates it to third-party agents – trusts, banks or other institutions purposely designated to maintain an investor's financial record - regulators and other legal parties. Operators can be either authorized or revoked to transfer tokens and their partitions on someone's behalf in the ERC1410 without each time being explicitily authorized by the token holder. In any case, they might force tokens' transfer between addresses as long as the contract itself states that this is possible – i.e., *isControllable*. Possible real-world applications refer to legal actions due to fraudulent transactions or fund recovery as a result of lost private key issues. However, due to the decentralized nature of Ethereum which was created precisely to avoid this kind of interferences, such actions should be completely transparent and emit flag events to keep track of them.

2.2.1.4 ERC-1404

The ERC20 has transformed the blockchain into an enourmous 24/7 exchange where fungible digital assets can continuously be exchanged without limitations. Indeed, classic exchange listings are not required by issuers to tap into public or private investors. However, limitations on who can make the trade – not contemplated on the ERC20 – are needed when dealing with securities. Therefore, around the time ERC1400 was released, the TokenSoft, a primary issuance and compliance platform in the field of tokenized securities, announced the introduction of the ERC1404 EIP, an open source and platform agnostic ERC20 compatible token standard for the issuance of security tokens that builds upon the functions already constructed on the ERC20 interface, by adding the following two functionalities:

- *detectTransferRestriction*. It has value within the *transfer* and *transferFrom* functions and is arranged according to the issuer's logic. This function explores whether for instance the funds are subject to a lock-up duration or the recipient is not allowed to receive the tokens because has not been verified in terms of AML/KYC – thus resembling a permissioned network on a public blockchain. It returns a code that send back to the specific error that occurred during the code execution, which can eventually be used by third party operators. If the code returns 0 (zero), there is no transfer restriction.
- *messageForTransferRestriction*. It explains the reason why the transaction has been constrained in a human readable format.

This turns out to be a precious on-chain preventive measure that operators can call it to detect if and why a transaction is going to be restricted and provide a message to the potential token sender, without losing any gas fees for reverting the transaction.

2.2.2 Non fungible token standard

Non-fungible token standards are aimed at creating unique and – until some time ago – non-divisible digital assets, in the sense that they cannot be split or exactly changed for other non-fungible assets of the same type. These are used for representing tangible and intangible goods such as deeds, ownership titles, flight tickets, real estate or any other item that has unique properties and thus not replicable.

2.2.2.1 ERC-721

A non-fungible token represents itself its own smart contract that inherits from a given template every time a new instance of such a token is originated. This is different from fungible tokens as these latter can be created out of a single smart contract and they all report to the same originator. Moreover, another divergence is that every running instance of such a token contract contains a globally defined owner address field. Technically, what we call an NFT is nothing but a globally-unique combination of the contract address and the token identifier – i.e., token ID – retrievable within a smart contract.

An ERC-721 token describes functionalities typical of "non-fungible" tokens, that is, uniqueness. The concept of uniqueness introduced by this standard ensures that each token will be associated with a single, inimitable characteristics that makes them different from one another. The ERC-721 standard introduces the concept of uniqueness in digital assets and ensures that each token is associated with a single specific object, collectible or piece of art, with ownership being easily verified on the blockchain. This can help indeed to clamp down on counterfeiting and dispose of the original version. The standard defines the must-have functions. Some of them are ERC-20 compliant that make the smart contract act like a common cryptocurrency.

- *name*. Used so that other contracts and applications can easily interact with the token contract.
- *symbol*. Shorthand token name.
- *totalSupply*. Returns the total quantity of existing tokens available on the blockchain. Like the ERC20, it is not fixed and can be changed along the way by minting or burning existing tokens.
- *balanceOf*. Followed by holder's address, returns the number of tokens owned. However, this function has a different connotation from the ERC20's since it outputs the number of different assets held by the owner and not the amount – intended as times – of the same asset, since here each token is different from the other thanks to a unique mapping "*address → ID*". A token ID is an integer associated with the name of the asset – i.e., string.

The following are instead typical to the contract and serve to manage ownership of tokens.

- *ownerOf*. Returns the owner's address based on the token ID, which is uniquely traceable on the blockchain.
- *approve*. Endorse or grants another user approval to transfer tokens on owner's behalf.
- *takeOwnership*. It is applied when a user has been approved to withdraw the token from another user's balance had he been previously approved.
- *transfer*. It is used when token's ownership is transferred from one individual to another. However, such function can be initiated by the sender only if the recipient address has been priorly endorsed to own the token.
- *transferFrom*. Like in the ERC20, it enables to enforce delegated transfer. Differently from the fungible token standard, it should always be specified the token ID object of movement rather than the quantity for the asset, which is superficial. This is implied also for all the other functions.
- *ERC721 Enumerable (discretionary)*. This optional interface is composed of a group of functions, i.e., *totalSupply*, *tokenByIndex* – returning the token ID for each token index - and *tokenOfOwnerByIndex* – returning the token ID for each owner's address. In fact, as an address can own more than one token, each referenced by a unique token ID, it might be in the owner's interest to keep track of the difference IDs in circulation. These identifiers are organized in an array, retrievable through the latter function by means of tokens' indexes, which correspond to the *totalSupply*. The choice of the token ID is arbitrary and submitting to the logic of the issuer.
- *tokenMetadata* (discretionary). Since what make a token inimitable are indeed their attributes in terms of metadata and generally these are expensive to store on the blockchain as they sharply raise gas costs, a way to record them is by means of references that consist of HTTP or IPFS protocol links or hashes living outside of the blockchain and linked to each token's attribute, i.e., data of data. This is actually an interface that hosts a set of functions, one of them being the *tokenURI,* that returns a string pointing to a URI link that hosts the JSON pattern that describes the token's metadata. Basically, this function allows to know where these data of data – "metadata" - are saved and the route to retrieve them. *Name* and *symbol* fall inside this interface as well. An example of a metadata JSON scheme is reported below. The arrangement of a token metadata is completely discretionary, managed off-chain and follows no standards.

```
"title": "Asset Metadata",
"type": "object",
"properties": {
    "name": {
        "type": "string",
        "description": "Identifies the asset to which this NFT represents"
    },
    "description": {
        "type": "string",
        "description": "Describes the asset to which this NFT represents"
    },
    "image": {
        "type": "string",
        "description": "A URI pointing to a resource with mime type image/* representing the asset to which this NFT represents.
    }
}
```

Figure IX - ERC721's metadata schema in JSON

Two more functions are implemented, i.e., *safeTransfer* and *safeTransferFrom*, in the case the recipient is not a normal wallet but instead a smart contract. What these functions perform is to make sure that the receiver has some functions "pre-installed" in their contract to prevent tokens from being lost.

As per the events generated by the ERC721 they are the same of the ERC20's.

- *approval*. It emits details of whose current owner have approved address operator for a particular token ID to own the token anytime the token address is set or gets changed.
- *approvalForAll.* In case the operator can manage all the tokens of the owner it emits details whenever he gets authorization or not.
- *transfer.* This event is triggered whereby a token alters ownership, in particular indicating which accounts were involved in the transaction and the specific token ID.

2.2.3 Semi fungible token standard

When it comes to NFTs, one of the main issues is that the ERC721 forces to create one contract for each specific type of non-fungible token – also known as collection. Any time somebody liked to generate a new NFT, he would have to build another smart contract rendering the whole system way inefficient. The same applies to ERC20 by means that each token type compels deployment of distinct contracts. This means that lots of blockchain memory is filled up by superfluous bytecode, making gas costs skyrocketing. Furthermore, the obligation to create different smart contracts into their individual "permissioned" address sets an edge over the functionalities that can be achieved like for instance the need to approve these contracts separately one by one when using a certain platform.

2.2.3.1 ERC-1155

A more flexible standard that combines tokens' fungibility and non-fungibility characteristics was introduced under the label "ERC-1155 or multi-Token standard", from

the Ethereum Improvement Proposal number 1155. It was released to specifically target multi-token economics dApps - i.e., manage multiple token types at the same time - allowing different token's types to be created within the same instance of a smart contract, improving limitations of both ERC20 and ERC721, to such an extent that it has become very popular in the blockchain space - Rarible, Opensea and other marketplaces allowed support to mint tokens with this standard. Let's think of collectibles-based dApps with different typologies of in-game items and how such a standard could be useful to address these use cases.

By looking at how an ERC721 is designed, besides a unique correspondence between IDs and addresses, one major limitation on lies in the obligation to have just one single asset for each token ID and thus owner – since there is just one single owner for each NFT -, while the ERC1155 allows for a configuration in which the number of assets itself tells if that token ID is associated to a fungible or non-fungible token. Following this logic, an NFT becomes just like an ERC20 token with a quantity set to one. This is done through a double mapping *address → tokenID → balance*. Indeed, any tokens' combination is achievable.

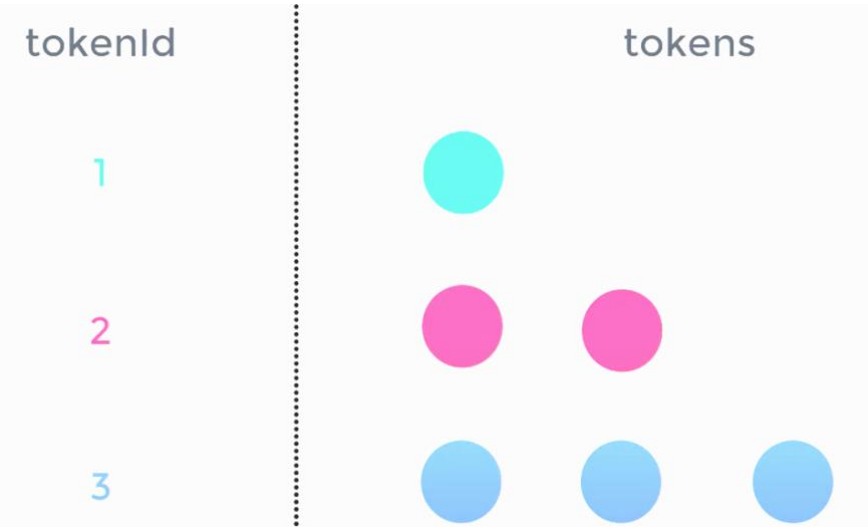

Figure X - Relationship between tokenID and tokens' balance

In this section, just the differences with respect to the ERC721 design will be investigated.

- *(safe)TransferFrom*. This function is designed to handle both normal and delegated transfer. Data can be attached if the recipient is a contract. If the prefix *safe* is used, then the receiver needs to have specific ERC1155 configuration inside its contract.
- *(safe)BatchTransferFrom*. One breakthrough introduced by theERC1155 is the possibility to send tokens in batches. Transactions can be bundled together and multiple token types in different quantities can be forwarded to different parties all in one go, thus increasing the efficiency and saving lots of gas fees. When calling this function, an array of owners' addresses – recipients – and tokens' IDs

needs to be specified. It might also be the case that more tokens' IDs belong to the same address. If the prefix *safe* is used, then the receiver needs to have specific ERC1155 configuration inside its contract to handle batch transfers.
- *balanceOf*. It returns the owners' balance by inputting the token ID and the transfer owner, slightly differently from what happened with the ERC721.
- *balanceOfBatch*. This is like the previous function unless the user can specify an array of owners and tokens' IDs.
- *setApprovalForAll*. They enable to identify the address – i.e., operator - who will be able to spend all the tokens on someone's behalf, accompanied by a boolean variable that states if the user is authorizing or revoking the permission. This function does not return anything.
- *isApprovedForAll*. This function enables to check whether an operator's address has been approved by a certain owner to act on his behalf.
- *tokenMetadata* (discretionary). Inside this interface, the function *symbol* has been removed because it is thought to be considered useless and lead to collisions, i.e., pointing to the same shorthand name. Another change was to remove the *name* function from the standard and transformed it into a JSON metadata attribute (off-chain) to avoid data repetition, thus using it to directly localize assets' name inside the JSON schema.

2.3 Opportunities offered by tokens - the Web evolution

Since Tim Berners-Lee, creator of the World Wide Web, successfully implemented the first HTTP communication over the internet in 1989, the web has continued to evolve relentlessly until it now plays a major role in our lives. This paragraph aims to analyze how the web has evolved by analyzing the current problems and how blockchain tokens can be a useful tool to solve them.

2.3.1 Web 1.0

The first version of the web, Web 1.0, was characterized by static read-only content – information economy. The first example of the World Wide Web was nothing more than a series of web HTML pages where information was displayed in an appealing visual form and shared without any possibility of interaction, except for normal hypertext navigation between pages, the use of email and search engines. Content could be modified only by administrators or by website proprietary upon web server. The focus was on the communication of information. Anyone publishing a website made information accessible to anyone, breaking down geographical boundaries for the first time and laying the foundation for a global information system. However, it is a unidirectional flow of communication that aims at the market without considering its wishes or proposals.

Web 1.0 marks the birth of the New Economy thanks to the possibility of reaching new frontiers of commercialization where innovation resided in information as an exchange

good: companies such as Yahoo, Netscape, eBay, Amazon, ... - many of which then failed - the first to realize the enormous potential of this new technology.

2.3.2 Web 2.0

Starting from the 2000s, thanks to faster connections and more functional software, it becomes possible for users to create and share contents obtaining a social web that shifts the attention on users. This is the birth of Web 2.0 defined as read-write web. Platforms enable to create tailored experience and contents start to become customizable. It is the origin of web applications and platform economy (Voshmgir, 2019). Blogs, forums but also platforms such as Wikipedia, YouTube, Airbnb, Facebook that put the user at the center in the creation, classification and creation of content and that still contribute to improving the quality of life of millions of people.

From a strictly network technology point of view, Web 2.0 is fully equivalent to Web 1.0, as the infrastructure at network level continues to consist of TCP/IP and hypertext is still the basic concept of the relationships between contents. It was not a technological evolution, rather a "front-end" revolution in which platforms remained to be controlled just by a single entity. The difference, more than anything else, lies in the approach with which users approach the Web.

However, Web 2.0 is not without its problems, the main ones herein reported.

- Data monopoly. There is no way to compete against web giants such as Microsoft, Google, Amazon, and Facebook whose nearly total web traffic and unlimited number of resources represent a barrier to entry for any other competitor.

- Non-possession and non-persistence of data. The data that we all give up on a daily basis and therefore lose possession of are often used in a very non-transparent way. Moreover, since data are saved on centralized servers, there will be the possibility of them being lost, removes or censured.

- Economic model. The model based on advertising and data analytics has started to experience problems, mainly to the detriment of content creators – who are paid less, if not completely cut out - and users – they don't know where their data is flowing. This model damages media companies - publishers - as well as they can't control the ads space and revenue drop consequently.

2.3.2 Web 3.0

Despite the absence of a standardized definition, the novel Web age is associated to a more conscious usage of the Internet through an enhanced semantic which harnesses AI, IoT and advanced Machine Learning algorithms to achieve a seamless user experience within an overcrowded network. However, many argues that the backbone of the Web

3.0 is the blockchain network and its "backend" revolution. In fact, it doesn't change how users interact with each other and navigate through the Internet.
Even if technology innovation boundaries are still blurred, there's an increasing convergence upon the concept of a more connected, transparent, safe human-centered network. There is a growing realization that web services should be decentralized, and one of the answers to such a transition may lie in blockchain itself. This could bring important benefits.

- Democratization of access. Anyone with access to an internet connection will be able to participate in the network without any discrimination.

- Data ownership, security and persistence. Users would regain possession of their data, being able to decide with whom to share them and in what way, even possibly being remunerated for doing so. Data will be stored in a distributed fashion, eliminating the possibility of data being lost or removed.

- Service uptime. There is no single point of failure for the infrastructure, which always remains operational. Internet-service providers outdated centralized servers do not represent a risk anymore.

Of course, it is early to draft conclusion about potential mass adoption of blockchain-based services as there are many challenges that need to be solved in terms of costs, scalability and above all user experience with respect to their centralized counterparts.

Figure XI - The Web evolution at a glance

2.4 The Internet Stack

Web 2.0 applications have been relying on dated communication protocols fostered by skillful developers and founded by third-sector businesses which required little management and designed to be hardware and software agnostic. Such freely used protocols have made a fortune to Google, Facebook and other tech giants who eventually reaggregated value in the form of data and making money out of it at the application layer. Having incorporated economic incentives around them, over time investing in these firms became more profitable to stockholders rather than barely capitalizing on the underlying protocols. This situation is perfectly described by the contradistinction between "thin protocols" versus "fat applications" in terms of how value is distributed, with the implications already discussed in under "Web 2.0".

Nevertheless, the advent of blockchain started to shake up this notion, especially due to decentralization. As barrier to entry are practically inexistent, there has been a growing number of niche protocols and protocol – native – tokens. For the first time the introduction of blockchain allowed creators to monetize upon the protocol they develop through tokens that incentivize users to behave according to the protocol's interests. The better a protocol, the more its perceived value that is going to benefit not only the value trapped by the token powering it but will also drive up the number of applications built upon it. Thus, an appealing protocol brings more value to the overall ecosystem, which in turns will attract even more users, developers and investors. Ethereum is the most striking example of this. The process just presented is referred to as the "token feedback loop".

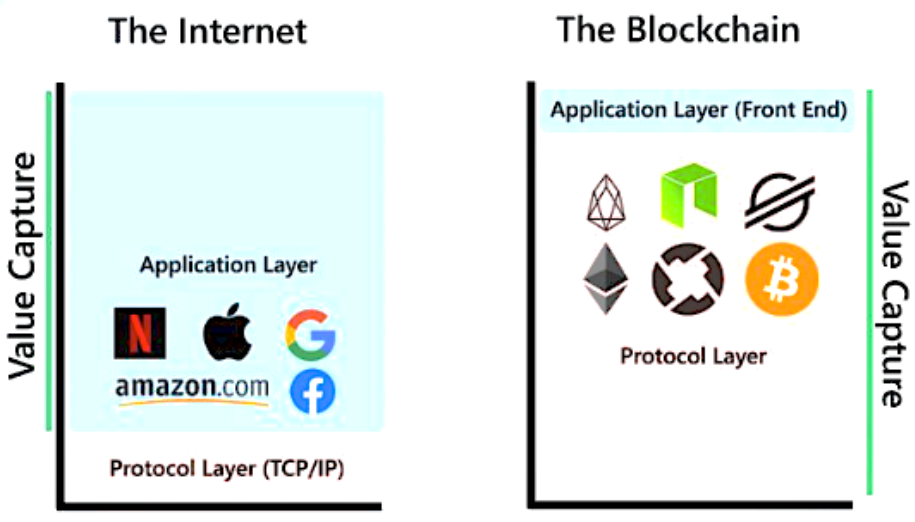

Figure XII - Value Capture distribution's differences between the Internet and the Blockchain models

This reasoning is also valid for already existing protocols enhanced by the advent of blockchain. Let's think for instance to Filecoin, which was introduced as an incentive layer for the IPFS protocol, a peer-to-peer hypermedia protocol for storing and sharing

data in a distributed file system, allowing people to be the custodians of their data, as well as making the web more accessible to people worldwide. Since participating in the Filecoin network by mining and storing is directly related to winning more block rewards, Filecoin incentives participants to act honestly and store as much data as possible.

2.4.1 The Metcalfe's law

The ability to choose from a myriad of different protocols for developing applications at very low costs on top has induced developers to opt for those networks that could already attract more and more users - i.e., Ethereum.
Technical and execution risks hinder businesses to develop complicated abstraction architectures from scratch and developers find it easier to create dApps by interacting with an extant protocol through smart contracts and APIs. Besides profits and control, there's limited reason why they would start their own network with few users connected when there are already plenty of on-going blockchains to cherry pick from.

This concept is clearly explicated by the Metcalfe's Law, which states that each incremental user adds more value to a network than the previous one. Such value "V" is proportional to the squared number of nodes (= N^2). Nodes can be users – active wallets - servers or computers. Having different set of nodes (apps) built on a shared protocol is way more beneficial for the overall network connecting them:

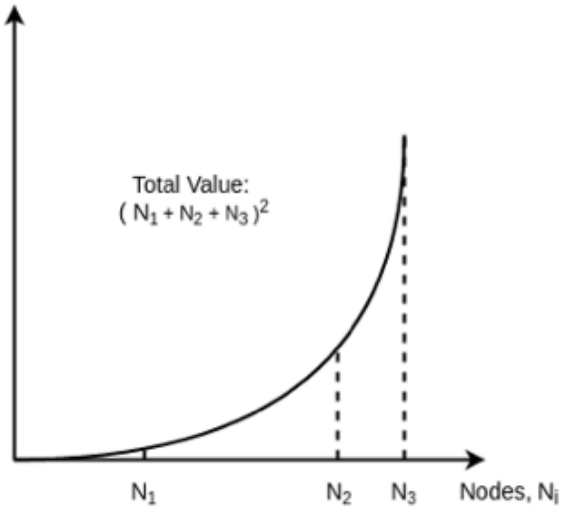

Figure XIII - A review of the Metcalfe's Law

By focusing on a shared protocol development, the entire system can grow synergistically. This has also an economic implication: it has been observed that typically the market capitalization of a protocol token will flourish faster than the joint value of the applications formed on top of it and tends to be closely related to the number of daily active addresses – users or applications using the network. Having dApp developers

attracting more users and opting for a given platform rather than another will encourage hardware and infrastructure development for that base layer to be improved, bringing in turn more projects and decentralized applications on top of it, and thus appealing even more users to join, in a virtuous cycle of network effects. This, however, calls for scalability solutions as a result of having a more congested network, discussed in the previous chapter.

2.6 Token Issuance models & Regulation

The creation of a Turing-complete blockchain has made possible to tokenize any scarce assets, from preorders in crowdfunding campaigns to ownership stakes, significantly broadening its disruptive prospective. it wasn't long before developers realize that it was possible to tokenize blockchain projects and sell tokens to fund them in a win-win solution as a funding alternative without passing through the "burden" of venture capital. ICOs emerged as this new fundraising form that involve global stakeholders from the very early-stage to attempt to build a solid community.

2.6.1 What is an ICO?

Like the offerings in stock markets, ICOs represent the first time buyers tap into a digital asset. However, investors are not purchasing any shares. In exchange for fiat money or other cryptocurrencies, early adopters are presold a certain number of liquid, tradeable and limited tokens, at a discount rate, that grant them the right to use future platform's services or goods. Ventures didn't have to undergo any legal scrutinization or advisory evaluation, which are instead compulsory steps of IPOs. The only thing companies were required to submit consists of a whitepaper, a roughly structured document outlining the technical aspects of a project, i.e., what it is about, the team back siding it, problems it aims at targeting, solution to those problems, how much money are they aiming to raise and their destination, and a roadmap for how it plans to succeed. The team usually reserves a percentage of the tokens created to fund the continued development of the project and remunerate those who have worked on it.

ICOs became extremely popular in 2017 following the explosion of interest in cryptocurrencies, having collected about $6.5 bn in that year only. Leading projects like Filecoin and Tezos raised record amounts of $257 and $232 million. During 2018, EOS managed to raised $4 billion. While respect to 500 ICOs launched over 2017 overall that raised a total of $ 7 billion, there were 537 ICOs launched just in the first half of 2018 alone, worth more than $ 13.7 billion. The volume practically doubled, giving rise to a market made of four to five hundred ICOs raising 2 to 5 billion a month throughout 2018. However, by 2019 the situation clearly started to change. Throughout the whole 2019 more than $ 3,3 billion USD have been raised in ICOs, that's equal to the amount raised amongst the end of 2017 and the beginning of 2018. After the ICO boom, the trend kept declinining as people have become skeptics about projects' offerings – for instance, it is estimated that in 2017, 20% of ICOs were scam - which slowly started to draw the attention of regulators. By today, projects looking for alternative funding are looking at a

rough path ahead and many argue that the time window following the ICO boom back in 2017 seems to be definitely sealed. In this regard, the SEC - the body in charge of regulating any securities offering in the US - has made several warning statements and created a scam ICO average template to protect investors from making hazardous decisions.

2.6.2 ICOs regulation

Any ICO suffer from information asymmetry which makes it difficult for the investors to assess them. Due to that and the vulnerability to money laundering and terror financing, many regulators published warnings on ICOs - i.e., AFM, 2018, BaFin, 2017, ESMA, 2017, SEC, 2017b. Countries like China and South Korea declared ICOs illegal in 2017. However, China has made it clear that this is just a temporary decision awaiting clearer indications. Other nations like Malta, Switzerland and Singapore are trying to position themselves as appealing countries for ICOs issuance getting ahead of it and remodeling their regulatory strategy in favor of DLT-based currencies.

In the United States, ICOs are not illegal in principle, but the Securities and Exchange Commission has not provided clear guidelines regarding the sale of tokens, stressing more than once how these funding forms should be considered like private placements, thus securities, and a case-by-case analysis should be privileged according to which instrument and their attached utilities are offered. What it matters is to look whether the token resembles the much contested and ambiguous term of "investment contract". According to the Howey Test, an *investment of money, in a common enterprise* and *with an expectation of profits largely or wholly outside investors' control, in the form of payment or dividends* - i.e., the network should be decentralized and independent from the company's work - are enough elements for the token to be labeled as security, thus falling under the Securities Act, 1933 and requiring mandatory registration with the SEC, but with the possibility to qualify for an exemption from registration – for instance, Regulation D that amongst others concerns private placements and allows issuance to a broader demographic of investors, assuming they're high net-worth individuals, banks or hedge funds. Unfortunately, there's no clear template for doing so within the SEC's current framework and to date, just two projects only - TurnKey Jet and Pocketful of Quarters - have passed the Howie as non-securities, getting away with a no-action letter from the SEC. Regarding stablecoins, no current legal framework exists – as they are considered a "niche" market accounting for $ 130 billion according to a 2021 Statista report - and their evaluation is deferred to the Howey Test as well. According to SEC 2019 *Framework for Investment Contract*, while they should satisfy the "investment of money" prong, the "common enterprise" and the "expectation of profits from third party" suggests stablecoins not being regulated as securities. Still, this might not always be the case. Earlier this year, USDT Tether came under heavy scrutiny after it revealed that around half of its reserves were made up of "*unspecified*" commercial paper. Moreover, in September, the SEC subpoenaed USDC issuer Circle as part of an ongoing investigation. A recent report from the Financial Stability Oversight Council argues that stablecoins could jeopardize the payments system and then recommends that Congress to pass legislation that would only allow banks to issue stablecoins – under the Federal

Reserve with the oversight of a federal agency to check for reserve deposits and assure availability - hence taking stablecoins out of the oversight of the SEC.

Debate at the European level is underway. Instead of investment contract, the EU legislation refer to the concept of "*transferable securities*" in the secondary market. Based on the Prospectus Regulation, in order to identify what constitutes a security, the EU courts focus around the *standardization* – fungibility -, *transferability* – ability to transfer ownership - and *negotiability* – capability of being traded on capital markets with ease - criteria. According to the EBA, *Report with Advice for European Commission on Crypto-Assets*, 2019 and ESMA, *Advice, Initial Coin Offering and Crypto-Assets*, 2019, no harmonized shared model subsists – the MiCA regulation for crypto assets is expected to be enacted by the end of 2023 and some member states have recently legislated independently on crypto asset issues, thus producing market fragmentation - and the main regulatory bodies are highlighting shortcomings in the current EU legislation on financial services – MiFID II above all. The MiCA lays out some standard operational, organizational and governance requirements for both prospective and established stablecoins and utility token issuers, with an articulated and supervision scheme – it does not apply to financial instruments, e-money, deposits or securitizations, already governed under MiFID. For instance, all stablecoins' issuers are required to own and maintain capital funds equivalent to either € 350,000 or 2% of their total reserve assets, whichever is the larger sum, percentage that goes up to 3 % for "*significant*" issuers – i.e., any issuer with a market capitalization of at least €1 billion recording at least 500,000 transactions per day. Currently, in the understanding of MiFID, only part of circulating crypto assets will qualify as financial instruments. This means that there is no protection for investors and consumers from the risks of scam, cyber-attacks and market manipulation. Supranational regulators stated also that the actual classification of crypto assets is responsibility of each individual State member implementation, suggesting anyway to privilege a *technologically neutral* approach.

In the United Kingdom, Italy and Germany, ICOs should be analyzed on a case-by-case basis – following the approach of *transferable securities* - according to the rights that the coin holder obtains. However, in these countries, cryptocurrency tokens might be regulated under banking or e-money laws – requiring a license - and not considered investment products, except for Italy. In the peninsula, CONSOB, *Final Report on Initial Coin Offerings and Crypto-Assets Exchanges*, 2020, stated that – besides the lack of specific regulation - requirements authorization to financial authorities is needed only for public investors. In Switzerland, the Swiss Financial Market Supervisory Authority distinguishes three token typologies offered in an ICO according to the underlying economic function, i.e., *payment, utility* and *asset token,* claiming that only the latter of falls into the security realm. For what concerns ICOs of payment tokens, pre-financing - i.e., investors offered only the prospect that they will receive tokens at some point in the future when either tokens or the underlying blockchain remain to be developed - and pre-sale - i.e., receive tokens which entitle them to acquire other different tokens further in time, whose claims are also tradable – must be registered as securities. In Spain the regulator stated that all kinds of ICOs are categorized as public offerings of negotiable securities subject to strict requirements - with no distinction between tokens and cryptocurrencies. Similar reasoning is applied in France, where the parliament adopted a new legal ad hoc

framework in 2019 – named PACTE, Action Plan for Business Growth and Transformation – by which ICOs addressed to the public needs first financial authority approval. In Malta, ad-hoc regulation has been legislated. ICOs issuers must be priorly endorsed by a third-party agent, in charge of assuring technological and financial compliance. Moreover, non-accredited investors are not permitted to invest more than a certain threshold – i.e., $5 000.

US legislation *Main criterion*: investment contract (Howey test)	*EU legislation* *Main criterion:* transferability
Criteria that classify an investment contract: • A common venture → No individualized rights → Investors' funds are pooled → Income and expenses are distributed proportionally • Expectation of profit → Dividend, return, or payment • Managerial effort of others → Expectation of a person or group to carry out managerial or entrepreneurial efforts • Investment of money (fiat or cryptocurrency)	*Criteria that classify a transferable security*: • A class of securities → No individualized rights → Set of identical, fungible objects • Functional equivalence with ordinary securities → Profit participation → Stake in partnership → Voting rights • Transferability & negotiability → Ownership transfer is possible → Security can be traded easily in a structured market setting → Relationship between issuer and investor is clearly defined through membership rights and monetary streams

Figure XIV - Main characteristics for the legal classification as securities under US and EU legislation

3 Taxonomies of crypto assets in literature

With the emergence of blockchain-based projects for every unconceivable domain and a rising aspiring vision on what the technology can truly accomplish, there has been a corresponding increase not only in the number but also in the complexity of token design and one of the most arduous challenges is to gain full understanding of them.
The present paragraph aims at wrapping up the existing knowledge on the different taxonomies proposed in literature, to further anticipate which topics have not yet been covered, ultimately leading us to the definition of the research questions that this paper aims at answering.

A review of scholarly papers and grey literature has been conducted. The academic papers examined were looked upon the main scholar publication platforms such as Scopus, Mendeley, ResearchGate, … by typing keywords like "Crypto assets taxonomy", "Crypto assets classifications", "Blockchain tokens classifications". Valuable contribution seems to come from industry-driven and practitioner research and scholar papers on this topic are still lacking and build upon extent contribution of few academics.

Different types of crypto assets classification have been proposed in literature, analyzing them from a wide range of perspectives – economical, financial, accounting, legal, etc.… - and degree detail. Discarding the regulatory viewpoint – where the general recognized distinction based on the underlying economic purpose and a technology-neutral

approach is the one made by the FINMA, already discussed in the previous chapter - contribution of academics goes beyond the legal status to enter socio-technical, technological, governance's, informational and other economical aspects domains. Whilst the latter was a topic highly discussed back in 2017 due to the adoption of ICOs and scams to accrue genuine token distribution models, taxonomies that aims at providing a 360-overview of the token ecosystem do not lack. Existing frameworks are designed to help and bridge the gap amongst investors, business executives, regulators and the industry – also with the current financial system - as a whole to gain a holistic understanding of the crypto asset landscape to ensure that a consistent view of the different types of assets is provided and a common set of terms and definitions is established, as acquaintance about economic and business repercussions is still fragmented.

Attribute	FINMA	Oli. et al.	Bal. et al.	MME	ITSA	EEA	CC	Vosh.	Amazix
Claim structure	x	x		x	x			x	x
Technology	x	x	x	x	x	x	x	x	
Underlying	x	x	x	x	x	x	x		x
Consensus/Validation			x	x	x		x		
Legal status	x	x		x	x		x	x	
Governance		x	x	x			x		
Information complexity			x				x		
Legal structure	x			x					
Information Interface			x			x			
Supply		x	x			x	x	x	
Issuance		x	x			x			
Redemption		x	x			x			
Transferability	x	x	x	x		x	x	x	
Fungibility		x				x	x	x	
Expirability								x	
Rationale to possess		x					x		x

Figure XV - Overview of the main attributes used in existing frameworks' literature. Attributes are derived either implicitly or explicitly. The table has been extended to other taxonomies and attributes found. Source: Ankenbrand, et al., 2020

With reference to the image above, when more variables are taken into consideration to describe token ecosystem to fit a multidimensional analysis, even if in principle the semantic is maintained, the terminology is subjective and not unitary, also with respect to a particular attribute. This is motivated by the focus on different assets' types across publications. Moreover, attributes are not always clearly stated in all these taxonomies and sometimes are derived implicitly by following the specific approach adopted by the authors (Ankenbrand et al., 2020). Overall, the publications of Olivera and Ballandies cover most of the attributes for each "macrodimension" and have undergone practical testing to review their robustness through on-field experts' interviews and questionnaires. A brief description of the different methodologies is provided.

Ballandies et al., 2018, provided a very exhaustive framework - followed by an experimental approach - composed of 19 different descriptive and quantitative variables,

touching four main spheres, i.e., *distributed ledger*, *consensus*, *token* and *action* - each with different subdimensions that can assume more values. The template was assessed by feedback from the blockchain community and applied to 50 current existing tokens using a Machine Learning approach.
It is interesting how the validation write permission and read permission, instead of being evaluated together, are separated and belong to the digital and the real-world – i.e., *action* – respectively. Tokens' properties are evaluated from a rather economical viewpoint – transferability, supply, burn, underlying, creation condition (due to what tokens are created), unconditional creation of new token not tied to actions or consensus. The conceptual architecture and how the elements are integrated with each other provided allow for a much broader reading of the whole token system. Action is intended as tokens granting access to perform/receive actions, goods or services in the real-world. Actions and consensus are seen as some of the underlyings of token unit's value and what it consists of, which are cryptoeconomic assets that reside on-chain (Arrow F, for example other tokens or executable code) or off-chain (Arrow G, for example goods, services or commodities). Transaction is called claim before become such.

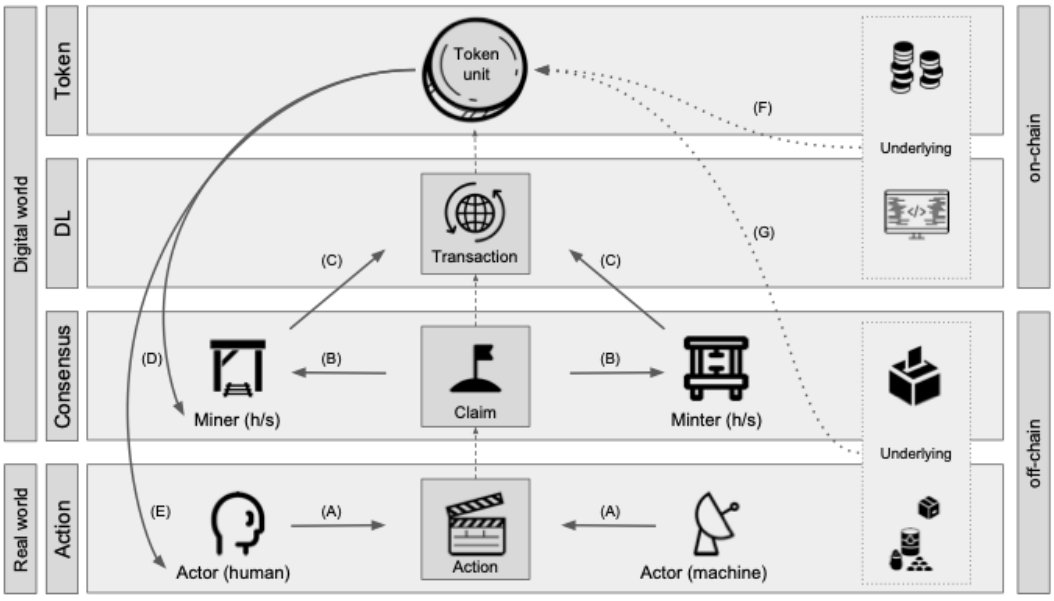

Figure XVI - An overview of the conceptual architecture containing the four key concepts of DLT systems and their relationship: action, consensus, distributed ledger and token. Source: Ballandies et al., 2018

If token units' creation happens because of an incentive system part of the DLT, there are two options: token units are given as rewards to nodes for either participating in the consensus mechanism (Arrow D) or carrying out an action (Arrow E) (Ballandies et al., 2018). In the case of Ethereum, for example, one type of action involves deploying a piece of code (Arrow A), such as a smart contract. These actions are collected by miners (Arrow B) and written as a block to the Ethereum distributed ledger (Arrow C). A miner who successfully writes a block obtains Ether, which refers to newly created units of a token that serves as an incentive to mine (Arrow D). The Ether token has inherent properties, e.g. it has uncapped supply. It also has value because it enables its owner to

access the on-chain computational power of the Ethereum network (Arrow F) (Ballandies et al., 2018).

Other solid industry-driven contributions come from the ITSA (International Token Standard Association, 2019), the EEA (Ethereum Enterprise Alliance, 2019), CryptoCompare (2018), AmaZix (2019) and from the consulting firm MME (2018) – the latter more prone to risk assessment and legal properties consideration, providing a classification based on token's function or claim – main use -, underlying, alongside other criteria such as the existence of a counterparty. Moreover, they provide three different archetypes – i.e., native utility tokens, counterparty tokens and ownership tokens, subject to other subcategories (Mueller et al., 2018).

The ITSA's framework "International Token Classification", or ITC, encompasses all the main dimensions – economical, legal, regulatory and technological - for a total of 11 attributes, and applied already to 800 cryptographic tokens and targeted to institutional investors that have to define their investment strategies as well as regulators. It divides regulatory – which assess tokens' legal status in US, China, Germany and Switzerland - from the legal perspective – i.e., (legal) claim structure, relative (contextually from a third-party), absolute (exist independently from a third-party) or no claim - and issuer type – i.e., which institution at legal level is issuing tokens. Economic perspectives consider token's main function from a high-level viewpoint – i.e., utility, payment and investment -, distribution and the industry where it is employed. The ITSA suggests also that the term "cryptocurrency" and its meaning is quite unclear since belong to all tokens, thus they have preferred to exclude it from the analysis. They are looking to expand the template with future work (ITSA, 2019). Interesting is that they are working on the introduction of the so-called "International Token Identification Standard", a nine-digit unique identifier for each resulting token, similar to the 12-alphanumeric code Securities Identification Number (ISIN) under ISO 6166 developed for traditional financial instruments. The ITINs, according to the ITSA, would be associated to each token currently on the market and also upon request of the issuer. In any case, the development for a generally accepted standard will provide safety, transparency, clear identifications, besides of course an open and free-market standard (ITSA, 2019).

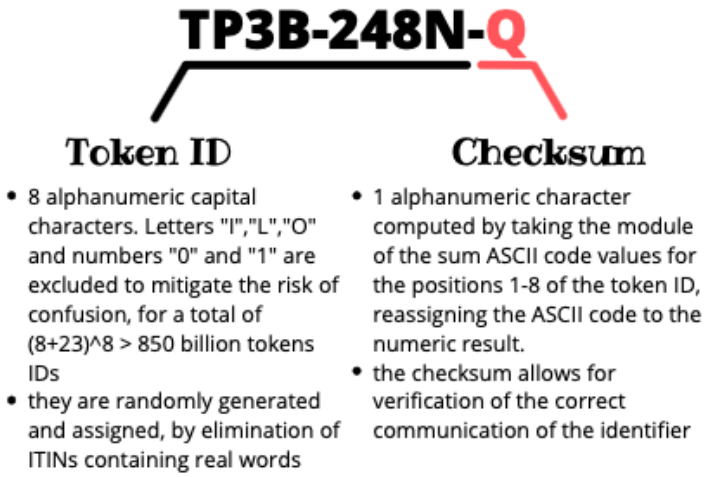

Figure XVII - Composition of the ITIN

Despite its practicality and original elements to be soon launched like the ITIN and TOKENBASE - the go-to soon to be launched standard multi-dimensional token database for the analysis of DLT and blockchain-based cryptographic tokens -, the framework does not seem to enter too much in details in terms of utility tokens – subcategories are not specified – as also stated by the authors themselves.

Another extensive classification framework along the lines of the ITSA is provided by CryptoCompare, covering a total of 30 attributes and 9 different archetypes, analyzing in depth more than 200 crypto assets. The taxonomy subdivides utility tokens into platform vs non-platform tokens – these latter can either be defined or general. Platform utility token is intended as an instrument to access a general-purpose decentralized network while on the other hand, non-platform ones indicate open networks designed for a specific use case – general, e.g., decentralized exchanges– or used to provide access to more traditional set of goods or services – defined, e.g., *consumer token* – and thus used on the network of just a single project. Non-fungible tokens are divided into personal – i.e., tokens specific not to themselves (attributes) but also to a particular entity towards which they point at such as reputation and identity tokens - and non-personal, i.e., collectibles and membership NFTs, which are not unique to a single entity. Two grouping criteria are of particular interest, namely the Rationale to Possess – i.e., reasons driving token holders to purchase and hold tokens, thus delivering a well developed classification as per the incentive they carry and induced behaviors of owners. Below, a summary is provided.

Figure XVIII - CryptoCompare's taxonomy. Archetypes are indicated inside the green boxes. Source: CryptoCompare.

The EEA proposed the "Token Taxonomy Initiative" (TTI) with the aim to provide a technology-neutral taxonomy to promote interoperability standards between different blockchain implementations. It distinguishes amongst 5 token characteristics that stress token features design – i.e., fungibility, fractionability, value (whether intrinsic or taking its value from a reference asset), representation (common, if they share a single set of properties amongst themselves, or unique, if tokens have their own identity with unique properties and thus univocally traceable) and type (single or dual parent/child token relationship called "hybrid").

Taking inspiration from the Burniske-Tatar's work, the taxonomy proposed by AmaZix tries to go beyond the classic catch-all definition of utility token and replace it with a more appropriate nomenclature, nevertheless embracing a financial-related point of view. It uses as a first discriminant the presence of a claim, that is, whether the token is a necessary and sufficient requirement to receive a flow of money - which it therefore calls "cryptocapital", among which it distinguishes in security and work tokens - or not - in this case the term "cryptocommodity" is used, then further divided into currency and collectibles. For each class, an explanation of the financial methods according to which such tokens should be gauged is provided – e.g., NPV, DCF, DVF, … - thus bridging the gap with the current financial instruments valuation frameworks.

Besides harnessing different attributes - technical, right, fungibility, transferability, durability, regulatory, incentive, supply, token flow, and temporal -, Voshmgir's framework provides a description of the technical design properties of the tokens, however without dwelling on business-model related aspects and context of usage.

To conclude, a precious contribution come from Olivera et al., "*To token or not to token: Tools for understanding blockchain tokens*" which derive a classification framework consisting of the 13 attributes – i.e., class function, role, representation, supply, incentive system, transactions, ownership, burnability, expirability, fungibility, layer, and chain - each of which include a set of different values for a total of 1.244.160 possible configurations (Freni et al., 2020). Then, eight different archetypes associated with their

main purposes (or reasons of usage) are derived by combining different token characteristics. The model was mapped against 18 different tokens but must be extended with future work and interviews.

- Cryptocurrency. Token with the ambition to become a digital form of currency. Main purpose/(es): currency.
- Equity token. A token which confers its holder a right to equity related earnings, such as profit-sharing, application rents or platform fees. Main purpose/(es): earnings and store of wealth.
- Funding token. Token which is perceived as a long-term investment from the holder's perspective and as a financing vehicle for the project's team and/ or the community (bounties). Main purpose/(es): funding and store of wealth.
- Consensus token. A token which is used as a reward to nodes to ensure data validation and consensus. Main purpose/(es): reward validation and store of wealth.
- Work token. Used to reward users who complete certain actions or exhibit certain behavior. Main purpose/(es): work reward.
- Voting token. Token which confers a voting right to its holder. Main purpose/(es): voting right.
- Asset token. Token which represents asset ownership. Main purpose/(es): voting right and asset ownership.
- Payment token. Used as application payment method in the application. Main purpose/(es): payment.

3.1 Gaps found and research questions

As mentioned at the beginning of the paragraph, one of the most complex challenges with the emergence of blockchain based project for every unimaginable domain is to gain full understanding of tokens and their designs, with profound implications over business models (Lewis, 2015). The literature published so far cover just blockchain-enablers specific applications and lack an implementation over more "traditional" use cases. Ankenbrand et al., 2020, go in this direction thanks to a classification framework that is asset-neutral, however this is achieved by analyzing correlations just with the traditional finance industry. Kose et al., 2020, provide a rigourous statistical and learning methodology that embrace industrial segments in which crypto assets are operated with a focus on automated classifications and limiting to classify tokens according to the FINMA's asset typologies. Instead, the work of Olivera provides a sound framework methodology spanning various dimensions but disregarding sectorial coverage. A mixed approach was pursued to try to fill this gap, strengthened by the existence of fewer empirical studies based on practical applications of such concepts to traditional companies' businesses and implications to corporate and governmental projects.

These shortages have inspired the questions that this paper aims at answering.

RQ1. Which are the sectors in which companies are employing tokens today?

RQ2. Which are the most impacted processes that follows the adoption of tokens in traditional private and public enterprises?
RQ3. Which types of digital assets are the most diffused and in which way are integrated into current companies' business model?

3.2 Limitations and future research directions

The taxonomy offered aims at establishing down-to-earth empirical evidence and links with a particular focus of traditional private and public business domains, by expanding the scope of application of extant work in literature. Nonetheless, not all the variables turned out to be relevant for the analysis of the census and to the purpose of the research questions. With respect to the sources of information harnessed, even if in principle it was interesting to analyze them, some information related to the economics were not complete to the extent that could be integrated in an insightful way to the analysis and hence, have been excluded. Despite covering relevant concepts majorly accepted in literature and being able to identify recurrent patterns in tokens' adoption, the sample is fairly thin and could be further extended. Moreover, the research lacks an investigation over tangible and quantitative benefits that asset tokenization brings, limiting to state just qualitative considerations as per the causes that drive businesses towards tokens adoption.

As new projects rise at a frightful speed – at the time of writing there are as many as nearly 17 000 different tokens in circulation, just the ones publicly traded (CoinMarketCap) – blockchain-based tokens' variety and endless application domains stress the need of adequate and coordinated approach through which businesses, investors, regulatory entities, and policy makers themselves can effectively untangle to have a complete understanding of digital assets – not just from an investing perspective. More specifically, if on one side the technical aspects have been thoroughly explored, defined, and diverged into different deployment frameworks (Freni et al., 2020), the business and social implications are still blurred, and this is what future research should address through data-driven real-world cases analysis.

4 Research methodology

The model aims to classify the various types of tokens or digital assets introduced in projects launched by corporations involved in the use of blockchain, or more generally the DLT system, as an underlying technology, from 2016 to the current year, and then provide a more general overview about their adoption and integration with their business model.

In this regard, and ultimately, so-called descriptive sheets built specifically to describe those most interesting tokens will be proposed.

The total number of projects surveyed amounts to 151, a number not too high but at the same time sufficient to obtain a discrete and, in a sense, solid database on which to carry out the study that will be presented in the following paragraphs. The census will extend the initial work conducted by the Observatory.

The number of projects encompasses news from past years that were already analyzed by the researchers of the Observatory and therefore revised one by one according to the new model developed (70) along with data coming from the current year, from January to October 4, 2021, to which the last project found was dated (81).

Amongst the projects much higher number of projects inspected, it must be pointed out that the use of this innovative technology does not always follow the explicit introduction of a digital currency or asset that regulates the ecosystem. It should also be underlined that the census focused on companies, both public and private, already consolidated and launched in their respective sectors. Therefore, start-ups or other small, high-tech companies were excluded.

Besides companies' official landing page, CoinMarketCap, CoinDesk, CoinTelegraph and Ledger Insights were among the main third-party sources for finding news, the latter of which being more linked to the entrepreneurial and corporate world.
Data collected through secondary sources publicly available from the internet, such as blogs or websites were triangulated, when possible, with official information provided by official companies' videos and whitepapers.

4.1 Census description

The model consists of 26 variables, exploded in details in the upcoming section and including the most general like status, nationality of origin, market, sector – industry - of belonging and impacted process.

Source & Date

URL link to the web page where the news ware found, associated to the day when the the headline was published.

Nationality & Continent

This attribute is used to indicate in which country the project has been launched, associated to its wider geographical area or continent. It may happen that more than one country is involved, therefore we will indicate "International" as country of origin and the name of the continent of belonging (under the variable "Continent"). However, if the projects is launched throughout the globe involving several countries, the key value "World" will be inserted in both columns.

Market

It is possible to distinguish between B2B and B2C based on the addressee of each project; C2C in case of marketplaces connecting end-users and the unusual abbreviation "P2C" which stands for Prosumer to Consumer, which will be explained later on.

Stage of development

The variable refers to the development stage of the underlying project to which the news relates to.

- Announcement: usually following a press release announcing the commitment towards a project; disclosure has informative purpose only and no technical specifications are provided, since the project haven't even entered the initial development phase yet.

- Proof of Concept: as the name suggests, its purpose is to determine the feasibility of an idea, a concept or to verify that the idea will work as expected. It provides valuable information regarding the potential benefits of the solution. The PoC can be in the form of a document – whitepaper -, presentation or demo, more or less detailed or complex.

- Pilot: refers to an initial roll-out of a system, targeting a limited scope of the envisioned problem to solve, such as may be a limited number of users who can access the system, business processes and stakeholders involved, or other restrictions. It provides a controlled environment to test the working system and seeks to address more quantitative issues that may rise.

- Operational project: the solution has been tested and proven with the necessary adjustments; therefore, everything is ready for the launch on the market at full capacity to consumers.

Sector

The variable stands for the sector of belonging of the company launching the initiative. To have a glimpse over the potential categories to be employed, a mixed approach was followed as two different models were taken as reference: firstly, the NACE REV2, the European statistical classification of economic activities which standardizes sectors' denominations and the CryptoIndexSeries (CIS) model, which breaks down the crypto asset market by sector. However, not all the categories provided were used and sometimes grouping or explosion of categories was done to reach a compromise.

To follow, the explanation of the sectors employed:

- Agri-food. It groups companies that deal with agriculture and food production along the whole value chain, from harvesting of raw products to final users' delivery.
- Art & Entertainment. It includes a "*wide range of activities to meet various cultural, entertainment and recreational interests of the general public, including live performances, operation of museum sites, gambling, sports and recreation activities*" (Nace Rev2).
- Automotive. It groups together companies involved in the production and sale of motor vehicles.
- Energy. As Eurostat cites, the sector deals with the "*activity of providing electric power, natural gas, steam, hot water and the like through a permanent infrastructure (network) of lines, mains and pipes. This section therefore includes the operation of electric and gas utilities, which generate, control and distribute electric power or gas*".
- Fashion & Luxury. It addresses high-end companies offering luxury products.
- Finance. It encompasses companies offering financial services such as investment funding, banking, asset management (including real estate) and stock brokerage activities. Fintech companies are included, even if they are technology driven.
- Government. This sector encompasses governmental and public administration initiatives, no matter the field of belonging.
- Media & Telecommunications. It comprises media and information dissemination companies. Telecommunications and data transmission companies are embraced.
- Mining. *It includes include primarily the extraction of minerals occurring naturally as solids (coal and ores), liquids (petroleum) or gases (natural gas*) (Nace Rev2). Other activities such as distribution and exchange pertain to such category in any case.
- Technology. It comprises those companies involved in the delivery of infrastructure-as-a-Service and blockchain-based general-purpose software solutions.
- Transports. This sector encompasses those incumbents involved in the handling – import export - of goods. Travel and airline companies are also included.

Main Process & Secondary Process impacted

This attribute considers which business process/(es) is/are affected by the project in question to get a better overview of what step of the value chain the project focalizes, whether back-end or more related to the front-end. The impacted processes have been narrowed down to the followings - eventual further processes involved are specified.

- Advertising Management. Encompass initiatives aimed mainly at rewarding users for participating in loyalty programs or engage fans through seamless experiences. Users might be rewarded for sharing their behavioral habits with the companies or endorse original content.

- Capital Markets. Projects involving the offering of long-term securities and other financial instruments like debt and equity through which governments and companies raise funds to finance their investments. This might involve shares or

bonds of first issuance as well as tokenization of real existing assets kept in vaults. A deeper overview of the present process is held within the paragraph of the analysis of the different token archetypes.

- Data and Document Management. Solutions involving storage, management, tracking, retrieval and exchange of electronic documents cryptographically signed to guarantee tamper-proofness and immutability. Blockchain provides a trusted, independent, and cost-efficient environment for multiparty record transactions (intellectual property, land registers, …).

- Identity. It is based on the decentralized identity paradigm, the processes involved aims at give full control of identity back to the user or object – to guarantee its authenticity-, through a collection of immutable and separately verifiable "claims".

- Payments. Practices associated to transfer of value among multiple parties, decentralized and peer-to-peer, partly bypassing the modern payment infrastructure and convoluted value chain.

- Supply Chain Finance. Solutions providing a set of financing solutions to buyers and suppliers generally involved in a B2B market transaction. Suppliers can request for early payments of their invoices while buyers stabilize the supply chain, thus achieving a win-win situation. Possible financing solutions imply third party providers like banks or capital market investors, who will act as counterparty. By connecting to companies' ERPs, Supply Chain Finance platforms enable to automate tasks like invoices upload, financing request and settlement.

- Tracking and Supply Chain Management. Aim is to gather activities that support end-to-end product visibility along the whole supply chain, like real-time monitoring and tracking (IoT).

Given the abundance of parameters used, four main groups or attribute categories were identified according to the similarities in the kind of information by them provided.

Hence, 4 main macro-groups were identified following the approach of Olivera et al., 2018, and Freni et al., 2020:

- Governance parameters
- Purpose parameters
- Coordination parameters
- Functional parameters

Governance parameters

They cover the technical dimensions referring to the protocol or applications on which the token is based on.

DLT-based platform

It refers to the name of the distributed ledger-based platform used by the system of devices to communicate with each other. It can be either owned by the firm implementing the project and developed ad-hoc for the purpose of the project (i.e., Proprietary) or leveraging an already existing platform (i.e., Existent) (Pereira et al.,2018).

Protocol

The protocol shapes the substructure of the blockchain. It is the set of rules that dictates how a blockchain operates, and that all network participants must abide to. So, it pertains to the software regulating the network, coded in the machine language specified by the producer. These rules may include the type of consensus algorithm, cryptography, the governance structure, the incentives or even penalties. Van Eijk, 2015, states that blockchain protocols are ecosystems on which other platforms work.
Like the previous attribute, it can take on two values depending on whether the platform uses a proprietary protocol (i.e., Proprietary) or relies on one that already exists (i.e., Existent).

Each of the above variables is complemented with another attribute indicating the corresponding name (of both the platform and the protocol), as long as the information was available.

Access to data

It aims at exploring whether the transactions and information recorded on the ledger are public and can be seen by anybody just by browsing on the blockchain (i.e., Public) or if their accessibility is restricted only to one or few participants of the trusted network (i.e., Private) (Toepffer and Thatmann, 2020).

Validation process

By looking more in depth at the governance structure and the kind of consensus implemented, the goal of such attribute resides in the eligibility of participants, not only to join the network, but contribute to the validation processing of the transactions (Toepffer and Thatmann, 2020).
The current attribute can take on the following values:

- Permissionless
- Permissioned

- Hybrid

A permissionless blockchain enables anybody to "write" upon the shared state in return for transaction fees or either participate in the consensus process for determining its validity and keep the ledger updated. An example of permissionless blockchain is Bitcoin.

On the contrary, a permissioned blockchain is run by a single or more than one (in the case of a Consortium) known entities who have the necessary means to detect the nodes that issue transactions or alter the state of the distributed register. Example of permissioned blockchains is Hyperledger Fabric, which is fully permissioned.

Lastly, hybrid blockchain lies in the middle by combining transparency of the former with speed and performance of the latter and represent a convergence of the two worlds – immutability and trust of public chains and scalability of private. Transactions generally can take place on a private chain but commit information only when public verification is required. Layer-2 solutions and sidechains, described at the beginning, are variations of such types of blockchains.

Purpose parameters

They are linked to the finality or scope of the token. To grasp the different nuances tied to the several value propositions and applications of tokens, three main attributes, with their respective sub-features, are identified to better address them.

Legal Class

This trait wants to focus on the most widely used distinction of crypto assets but according to the legal evaluation that authorities consider when a new token is launched on the market. Most of the academic papers found in literature tend to agree on the definitions provided by the Finma, 2018 and Bafin, 2018, i.e., payment or cryptocurrencies, utility and asset tokens, the latter intended as debt instruments or equity claims on the issuer. To date, any digital asset in circulation can be led back to one of the above typologies and can be he replicated with slight divergences in most of the jurisdictions scattered throughout the world aimed at regulating the cryptocurrencies' ecosystem. The reasonings of the regulatory bodies are also resembled in a slightly different way according to the Euler's, 2018 framework, by which three main options can be demarcated.

- Cryptocurrency. A de facto mean of payment, unit of account and store of value. Like Bitcoin or Litecoin, any of the native crypto assets by either governments or central banks, fueling their own main net, used as a mean of exchange and incentive to keep the blockchain up and on-going fall under this category. Currently, unregulated: in Germany for instance, according to BaFin, 2018, pure cryptocurrencies are not regarded as lawful operative currencies and not regulated by e-money laws either.

- Utility token. Built upon an existing protocol, it entitles the holder to access a product or service offered by a given platform in exchange for the coin powering the underlying blockchain. Its value is limited to their "utility" or purpose inside the platform and evaluation of regulatory entities seem in general independent of factors such as the intentions of token purchasers, the transferability and the existence of secondary markets for such tokens. Such tokens are exempted from being registered as financial instruments in correspondent jurisdictions, thus subject to loose regulation as one of the few things are required to exhibit is a whitepaper.

  Stable coins and other e-money tokens have been made to fall back on to this category since, despite having to comply in any case with some kind of regulation unlike cryptocurrencies – e-money or banking –, are not considered financial instruments.

- Security token. This category encompasses both tokenized securities and securitized tokens (Nasdaq, 2019). Explicitly referred to as financial investments, the former is essentially a compliant digital representation of a traditional security such as equity or debt that trades via a blockchain. Tokenized representation of stocks, bonds and derivatives are some examples. They entitle token holders to earn a profit (i.e., dividends or interests) sometimes in the form of additional tokens - not always the case – and even voting right. Even if in principle very similar, securitized tokens, instead, securitize a brand-new asset class that is intrinsically illiquid. As the word suggests, they are a direct consequence of the programmability feature introduced by blockchain smart contracts. In fact, such tokens enable assets to become much more liquid as they allow for fractional ownership or even other rights (e.g., voting) typically difficult to enforce in a real-world application. In the same measure of utility tokens, differently from tokenized securities, this latter typology is used to participate in an ecosystem but, in virtue of the similar rights to which they entitle, they are considered at the same level of traditional financial instruments and thus, subject to strict regulatory framework (i.e., MiFID II in UE and Securities Act in US). Security tokens, like utility ones, are built upon an existing protocol generally using ERC-20 standard (in case of Ethereum).

Function

This characteristic delineates the high-level functionality of the token in question, the reason why it exists according to the utility it provides (Olivera, 2018). According to the models observed, Tomaino, 2017 and Little, 2017 provide a partition into utility, work and hybrid tokens based precisely upon their usefulness within the boundaries of a DAO, a decentralized autonomous organization – condition that does not necessarily always materializes. Despite the distinction remains identical in Euler's framework, he talks about their significance regardless of the organizational context in which they are embedded. However, a token which owns an underlying, regardless of the form, might in

principle not possess any utility (Euler, 2018). Thus, the following options that can be assumed by the variable are proposed:

- Asset-based. It exclusively depicts an underlying asset, regardless of the form. This categorical value is further exemplified below under the section "Representation". An asset-based token may give rise to a claim over the underlying asset that it represents.
- Usage-based. Also referred to as access token, it bestows on its holder an access authorization just like a ticket or pass does. For instance, Bitcoin entitles holders of BTC to participate in the money transfer network, where ownership of the token is a pre-necessary condition to use the service. In case of Ethereum, holding the coin entitles the bearer to use the Ethereum Virtual Machine and smart contract functionalities – until Casper (Ethereum 2.0) release. However, Ethereum might work in principle also as a payment network even if discouraged.
- Work-based. It is employed either as a value container to remunerate a certain attitude or action performed by the participant that increases the value for the other users. Likewise, it may give rise to special "rights" to actively contribute to the network. For instance, in case of the Augur protocol, that work might come from an oracle, in the case of Maker it gives owner the ability to take part of in an organization that manages the stability of the underlying coin (DAI). In principle, in any proof-of-stake system, it allows those who own the token to put them in "staking" and be eligible to participate in the validation process. It may happen that some fees are included for the "work" provided. The concept of transaction costs is deepened below.
- Hybrid. It may happen that more than one of these properties are embedded in the same exact token, no matter the way in which they are combined. The constituting functions are in any case indicated in brackets. For instance, Filecoin (FIL) could be categorized, under the current model, as "Hybrid (Usage-based + Work-based)" as users not just need it to take advantage of the service – decentralized storage – but they need to own a certain amount if they want to be "providers" of the service and add to the ecosystem's growth.

Role

This hallmark enables to dive a bit more in depth into the realm of the down-to-earth use cases that multifaced tokens may have inside companies' crypto economies. The approach in creating a self-sustainable economy, the definition of the utility role/(s) is crucial when it comes to determining the final success or downfall of a business model. When it comes to the strategical and organizational decisions that shape companies' value proposition and help them create value within crypto economies, W. Mougayar, 2017 provides a meaningful contribution as per the behavior and roles – not necessarily just one - that a token might "play" within a blockchain network to accomplish a resilient "token-to-market" fit, highlighting how each role has a precise purpose.

Maintaining as reference the model used from the author, even if with small adjustments brought and explained, they possible values assumed by the variable are listed.

- Right. Detaining a token grants rights that might result in from more specific entitlements like ownership, governance, contribution actions and voting to more basic ones like accessing and usage of the underlying product or service offered. In this regard, a distinction between governance and voting rights must be made, even if in principle these terminologies appear to be interchangeable. In fact, while the former is usually employed within DAOs by letting participants (i.e., the owners of the platform) deciding on more delicate aspects such as consensus, transaction fee distribution and more in general the future of a protocol that will influence the fate of a platform and thus perfectly resemble the definition provided above of "work-based tokens", tokens entitling to vote on ordinary issues which depletes soon after are just a way to democratize and incentivize active participation in the ecosystem and does not carry any long-term impact over the platform's capabilities. Real ownership rights arise whenever a claim over an underlying asset is present. Given these conditions as predetermined for the analysis, it has been decided to associate the word "right" with the meaning property rights, since others type of right has already been touched by the previous variables. Instead, regarding the right to vote, it will be specified every time it appears. A different reasoning must be made for non-fungible tokens representing collectibles or digital art pieces since ownership or title of the token does not automatically grant IP in the content and in most cases, it does not give you the right to publicly display, perform, distribute, sell or otherwise reproduce the work for any commercial purpose (The National Law Review, 2021).

- Value exchange. The token is used as a medium of exchange inside a certain application or market, engaging holders in the creation of a transactional economy with other participants – buyers and sellers - and with the platform itself to spend it for the goods or services inherent to the ecosystem. It permits users to receive value and to spend it on services that are exclusive to the platform. No matter how they came into possession of the token: they might have earned it by active or passive work. The emphasis is on the establishment of an internal economy which must be self-subsistent as time goes by.

- Reward. Tied to work-based token, the current attribute points out tokens specifically received because of the platform's usage or given out to recompensate certain actions and behaviors that enhance the value of the overall network. Initially referred to as "function", since this label was already employed for other purposes, it has been changed in "reward".

- Toll. The token can be the pay-per-use toll for getting on the blockchain infrastructure exactly like when they charge you to use a highway. Academics in literature suggest in unison that this is tend be a property of "Usage-based" tokens, as they consider within these boundaries, among others, native tokens powering their own chain. However, according to the modeling built, the given role would be associated to "Cryptocurrency" as well. In fact, whenever a platform - usually public as stressed by our data - requires a fee to finalize a transaction, this must be rendered in native coin to who in charge of maintaining and keeping the substructure run smoothly (e.g., miners). The system ensures

that users have "*skin in the game*" (Mougayar, 2017). This term might sound too generic but makes the idea well that users have a personal investment in the organization and thus it is in their interests to make the network function seamlessly. Fees might likewise occur for running smart contracts to accomplish a explicit task, enforce constraints, paying for a deposit or even simple usage fees. With respect to the database, it is also used to indicate those utility tokens which exempt their holders from paying transaction fees (TOGLIERE STA COSA, magari nel db si puo lasciare cosi visto che è come pagare le fees ma con un token non nativo)

- Currency. Token as a *de facto* mean of payment, lowering the barrier needed to process end-to-end transactions in a certain market. Much like the "value-exchange" role, it exhibits the same functionalities: a very efficient payment method inside the ecosystem and transaction engine of value adopted by involved parties. Nevertheless, to make it distinguishable from the above one, such role has been associated only to those digital currencies – i.e., CBDCs – which embed some sort of legal tender that "value exchange tokens" instead do not possess, i.e., tokenization of money on blockchain to perform a delivery-versus-payment transaction without compulsory sticking to cumbersome and expensive procedure of traditional financial settlement.

- Earnings. This sub-attribute has purportedly been used to denote whether the holder of the token has rights over some sort of value redistribution or future earnings of an organization – "share-like" token - such as dividends, interests and royalties which does not directly come from his efforts and thus, intended to produce a profit, no matter in which form these earnings are issued, i.e., e-coupons, tokens, traditional financial off-chain cash flow (CryptoCompare, 2018) …. Thus, this value could represent as a further specification of the role "right" as per above but when a precise instance is verified. In case of digital assets associated to financial instruments, interests are cumulable by the token holder until the set maturity date, like in real-world applications. However, earnings are not exclusive to financial world applications. In fact, thanks to blockchains' programmability, as previously mentioned, new kinds of earnings are introduced. In case of non-fungible tokens, there could be cases of a smart contracts that is programmed to automatically assign and return a percentage of the sale amount back to the original creator any time a change of hands occurs. It must be kept in mind that these novel privileges might make the asset fall inside the "security" boundaries that many organizations would like to avoid.

Coordination parameters

They are tied to what the token represents and how this could impact the way a platform is ruled and managed to align incentives among token holders, i.e., what we introduced previously as "tokenomics". The choice for the name of following group of attributes

was preferred over "Governance", as suggested by Olivera, 2018, since one could think of it as the policy and rules followed by the platform to achieve consensus, but this is not the case. Instead, the terminology used by Freni et al., 2020, was more appropriate for the scope highlighted.

Representation

It indicates which underlying asset is referencing the token, thus providing indications regarding potential appreciation in value and where such value might come from. According to Glatz, 2016, tokens are like a digital identity of something, which can belong to different representational dimensions, i.e., digital, physical, virtual and legal. Ankenbrand et al., 2020, instead talk about crypto asset representation as the "technology" on which the asset is based on, i.e., whether physical or digital, maintaining the meaning intact. It has been opted for a mixed approach, thus coming up with the following values.

- Digital. It embodies those assets whose functionalities are valid only within the boundaries of the blockchain in which can be transferred and smart contract that created them such as tokens tied to digital collectibles entitling holders to privileges verifiable within the ledger. Differently from Glatz, such category embraces any real-world intangible assets that exist in the more general context of information system and that might have legal enforcements such as deeds, patents, licenses, bankable assets in banks' accounts or any other contractual agreement. Since this "branch" encompasses asset types that are in principle different from one another, the specific asset type to which they refer is indicated in brackets.
- Physical. The token is tied to an underlying asset that is a tangible good such as real estate and other physical objects or a commodity like gold kept in a vault and even raw material. Tokens backed by fiat money do not fall under this field as, besides lacking intrinsic value, they are simply code numbers in electronic systems, intangible per sè, thus "digital".
- No underlying. It might be the case of tokens which do not possess any underlying or collateral at all, being it digital or physical, and whose value is dependent entirely on network adoption and influenced by marginal demand and supply changes dynamics.

As we can see under the above taxonomy, despite some tokens are representation of real-world assets, they are still categorized as "digital" because of the considerations just conducted. Thus, one specification attribute has been added to the morphological box to make the distinction clearer, i.e., named "native token", which is a binary variable.

On-chain or Off-chain

This property wants to deepen whereby the underlying asset and the resulting privileges are meaningful just via the blockchain and therefore exist only within the DLT boundaries, i.e., because they have been issued directly on-chain, or conversely, the

token is a representation of a real-world asset or any other piece of paper which is enforceable "off-chain" and brought on the blockchain, the so called "digital twin". IBM researchers, 2018, have defined it "crypto-anchors" in the domain of management and goods tracking as digital fingerprints that proof a product's authenticity via the blockchain and whose link between the two "worlds" is accomplished through optical code labels printed onto the surface or NFC chips embedded in the product itself.

For instance, it may happen that a stable coin is crypto backed. Despite an underlying asset is present, it is significant only in virtue of the core technology which is based upon. Similarly, all non-fungible digital collectibles will be classified as native. On the contrary, pre-existing "blockchain-embedded" real assets kept in custody or at a vault will be categorized as "non-native".

Fixed supply

Coming to the tokenomics realm, this binary variable investigates to which limit amount can tokens be generated (Ankenbrand et al., 2020) and thus if the maximum supply is fixed (i.e., deflationary token model) – like XRP or BTC - or not (i.e., inflationary token model) – like ETH, which has a constant flow added to the circulation according to given milestones.

Issuance

This attribute reflects the logic by which tokens are issued and offered to users. In principle, every coin can be created in two ways: either through mining, i.e., consensus mechanism reward, or pre-mining, which is the act when some or the whole coin's initial supply is generated before the public launch to incentivize stakeholders, either founders or employees, in further development of the coin. According to Chen, 2017, three possible issuance methodologies can be derived.

- One-off distribution, pre-mined. The whole amount is handed out in a single solution, at fixed amount, technically appended/ allocated to the genesis block at the time of its creation. More common in private ecosystems, in which each transactions involve instantaneous payments delivered at once, occurring between two or more institution after tokenization of correspondent funds.

- Pre-mined, schedule based. It is the most typical choice for companies going public through ICOs which wants to reserve a part of the total supply to themselves, perhaps with the aim of benefiting from token price appreciation as soon as they become tradeable and take advantage of "*pump and dump*" schemes. That is one of the reasons why pre-mined coins are seen by the crypto community as unfair practices put in place by unscrupulous developers to get rich. In pre-mining, tokens are allocated to the genesis block according to the will of the team in predefined proportions for different purposes: research and development, marketing, legal & compliance, mining rewards, public and private sales, community incentives, …. The allocation process which takes care of hand

out undistributed coins initially locked in escrows is managed by smart contracts according to milestones and governance rules until max supply is reached - i.e., vesting schedule. Thus, pre-mined coins are usually held by a centralized authority.

Ethereum is one of the most noteworthy currencies to have been pre-mined before going public through the ICO and detractors of the coin sustain that the project will become even more centralized after the shift to Proof-of-Stake (cryptonews.com).

- Schedule-based. Distribution related to the process of simultaneous coin creation and distribution. Bitcoin is the clearest example of a project in which no pre-mined BTC were distributed.

Talking about "mined" coins might not be extremely accurate as a unique mean of token generation as it is associated only to those coins employing the PoW mechanism. Tokens are said to be "minted" when fresh new ones are created from scratch without performing any computer mining activity but using for instance a PoS consensus. Still, as soon as a contract is tossed, the team could decide to adjust the supply along the way by minting or burning new or outstanding tokens. Hence, for the purpose of the analysis, we will refer to as "mined" just to indicate tokens creation.

All this piece of information was retrieved from projects' respective whitepapers under the section "Tokenomics", and some data might miss.

Incentive system

Whether the purpose is bootstrapping, perform transaction in a frictionless way or create an economy, blockchain projects embed many types of incentives from users' standpoint. Lena and Oxana, 2017, proposed three different types of incentives that tokens might exert and condition users' engagement within a platform:

- Enter. Tokens grant the right to access a product or a network. Perks simply derive from the fruition of a blockchain-based service, but the user is not able to perform repetitive transactions with the platform or other users.

- Stay and Play. Besides the previous advantages, users have the chance to engage in transactions with the platform and/or with other users in exchange for transaction fees that will help the platform to grow and solidify. Transaction fees might not be the sole revenue stream or might not be a revenue stream at all. To give an idea, work-based tokens tend to perfectly match the criteria of such category, even if not the only case.

- Stay long-term. Users benefiting from an advantage to remain long-term which can stem from a valuable status obtained by the user to affect platform's growth– e.g., DAOs - or from participating in the revenue redistribution process (royalties, dividends, interests, token buyback).

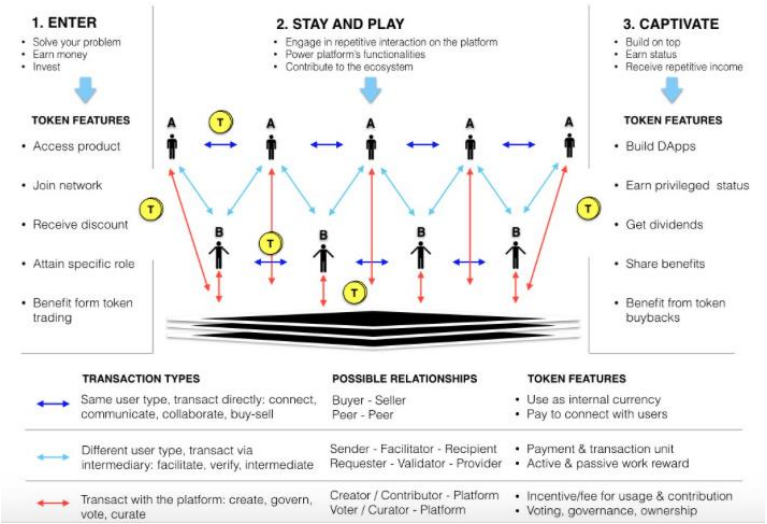

Figure XIX - Platform's usage incentives

Functional parameters

The last group of parameters incorporate the "-lity" properties (Olivera, 2018) which outline more targeted actions that can be implemented with tokens, offering a clear-cut portrait with respect to their specific functionalities. The following parameters can assume just two values – either "Yes" or "No", binary – and are covered in a more or less pronounced way in existing classification frameworks.

Spendability

As the term suggests, it refers to the ability of the token to be spendable. Referred to as "*Transactions*" in Olivera's paper or "*Redemption*" in Freni et al.'s, the term points to the same meaning since both terminologies signal a situation in which the holder swap – spend - or redeem its token/(s) with goods, services or discounts offered by the platform (Brammertz et al., 2018; Olivera et al., 2018; Ballandies et al., 2018; EEA, 2019).

Tradeability

it deals with the concept of ownership and token's transferability (FINMA, 2018; Mueller et al., 2018; Freni et al., 2020). Most of the times tokens' ownership may pass to another person (i.e., tradable) through the existence of secondary market trading or other marketplaces, though there are circumstances where this is not conceivable (i.e, non-Tradable). For instance, there are platforms that do not enable to monetize over a

reward by trading the prize. Some other platforms exchanging registered securities might prevent holders from transferring them to other parties via sale or giveaway.

Burnability

Not supported by evidence in literature besides Olivera, 2018, this attribute points out whether the token can be (intentionally) "burned" to accomplish artificial scarcity – such as shares buyback - or to manifest the extinction of a right or permission – for instance, whenever a user decides to withdraw his funds in return for the coin or move across different blockchain layers. However, since this latter element was not easily verifiable and distant from the original concept we intended, token burning would be associated to an act managed by the team which grants the possibility to repurchase outstanding tokens and send them to an address whose private keys are lacking so that the funds are not recoverable or likewise, through transaction fees, so that any time a transaction is performed, the fees paid to pull it off go directly to a "burn address". Burning could take place once or periodically at given time intervals – e.g., Binance – or can be incentivized through a reward. To tell the truth, token burning, according to its meaning, is in some ways connected to the governance aspects of a coin analyzed previously but the decision to associate the attribute to others more "functional" was made as to follow the Olivera's approach.

Expirability

This feature distinguishes between tokens which expires from tokens which do not. Again, this characteristic was stressed by the data even if not present in any of the classifications examined. Some tokens reflecting warranties or traditional securities like future and bonds do expire due to their nature. Moreover, it could be the case of tokens that are rendered unusable after some time. We can think of expirable tokens as those assets like one use only tickets or casino chips that are exchanged against fiat currency to access a certain application, without no threshold on the upper supply and affordable prices dependent on who is the provider of the service. On the other hand, tokens that do not expire can be seen as those that are indeterminately usable and that can be traded from side to side with no pretended expiry restrictions. Since they hold some sort of intrinsic value, they are used to power a circular economy and their supply is generally limited

Fungibility

It indicates whether tokens are interchangeable with other assets of the same type (i.e., fungible) or not (i.e., non-fungible). NFTs' widespread are one of the reasons that made such classification essential, so that is widely accepted and used in both academic and grey literature (Olivera, 2018; EEA, 2019; Toepffer, 2020; Freni, 2020; CryptoCompare, 2018). However, ultimately, the diffusion of hybrid standards has led us to include also this aspect.

Token archetypes

Several tokens display a multi-purpose capability since they often serve more than one purpose concurrently and overlapping of values assumed by the attributes have led to the composition of token archetypes, i.e., recurring patterns derived from a combination of different parameters from the morphological box and shared by tokens employed from similar blockchain applications which play a similar role in their respective business models. Ultimately, the implementation of token archetypes constitutes a way to provide a wrap up to accommodate the heterogeneity of tokens functionalities. Thus, labels assigned to token archetypes have the final aim to provide indications concerning their function and long-term value within the principal business model.

- Cryptocurrency. Token with the ambition to become a digital form of currency. it is a value itself, as it is a drive gear for transactions because users pay coins as fees for transactions. More generally, cryptocurrency is a motivation for miners who create and maintain a blockchain network infrastructure and ensure the security of the system.

- Payment token. Used as application payment method in the application. It includes stablecoins and central bank digital currencies.

- Work token. Used to reward users who complete certain actions or exhibit certain behavior. It steers collective actions by incentivizing individual contributions to collectively maintain a blockchain network. The data stressed how work tokens are generally used also as payment mean inside the ecosystem they belong to. Amongst work tokens, there are loyalty crypto coins which, instead of the traditional "points" as we are used to, they power a circular economy and are tradeable amongst members of a platform.

- Asset token. It represents an asset ownership over an underlying, whether being it digital or physical. Amongst the different projects, Identity Tokens, i.e., tokens hosting identity-related information, and Traceability Tokens, i.e., digital "passports" of objects, are included in this category as possible sub-archetypes.

- Membership token. This archetype was stressed by our data, which made us include it as a standalone category. Just by holding this token inside a user's wallet, it entitles them to added benefits such as access to a restricted community, exclusive merchandise drop, exclusive content, full commercial usage rights, access to other limited-edition items and other member perks from business to service access. Think for instance of a real-world ticketing platform. If you buy the token of such platform, you as owner will be entitled to have a reserved access for your favorite concerts and buy them before other do. Alternatively, think of a car manufacturer and how holding the car brand's own one would grant you early pre-registration in in purchasing the vehicle.

- Equity token. Such as traditional shares, it confers its holder a right to equity related earnings such as profit-sharing and dividends due to the purchase of a portion of the company's equity. Tokenized real estate are included in this category, as long as they are offered in the form of capital.

- Funding token. Instrument that is perceived as a long-term investment from the holders' perspective and as a financing vehicle for the projects' team/ community. It might represent debt instruments, notes, bonds or other instruments used in Trade and Supply Chain Finance, entitling holders to receive a fixed price or interest payment over time, but still working as debt financing vehicles.

- Consensus token. Token used as a reward to nodes which ensure data validation and consensus. This is similar to the Work Token archetype explained above, but rather used for actions that are tightly connected to consensus mechanism activities. In fact, a case-by-case analysis suggested how some work tokens also behave to promote consensus. This token is generally employed within open permissionless networks where a consensus is necessary for these ecosystems to function properly. To provide an example, any cryptocurrency that function on a Proof of Stake consensus protocol would also fall within this archetype.

- Voting token. It entitles the holder to take part in the internal voting process of the platform. Generally, this benefit is associated with what are called "Governance Tokens" in the context of decentralized application ecosystems. In fact, this token enables users to take part in the approval of protocol changes' decisions and participate in the revenue-stream of the platform itself. However, there can be systems in which each token is worth one vote and thus, cumulating them is profitable while others that function with the identity of the holders. In the case of securities, they enable the holder to participate in the shareholders' meeting.

Development stage	Process Impacted	DLT-based platform	Layer 1	Access to data	Validation Process	Legal Class	Function	Role	Representation
Announce	Advertising Management	Proprietary	Proprietary	Private	Permissioned	Cryptocurrency	Asset-based	Right	Digital
PoC	Capital markets	Existing	Existing	Public	Permissionless	Utility	Usage-based	Value exchange	Tangible asset
Pilot	Data and document management					Security	Work-based	Toll	
Operative	Identity management						Hybrid	Reward	
	Payments							Currency	
	Supply chain finance							Earnings	
	Tracking and supply chain management								

On-/Off-chain	Fixed Supply	Issuance	Incentive System	Spendability	Tradeability	Burnability	Expirability	Fungibility	Archetype of belonging (Olivera, 2018)
Y	Y	One-off	Enter	Y	Y	Y	Y	Y	Cryptocurrency
N	N	Schedule-based	Stay and Play	N	N	N	N	N	Equity tokens
		Pre-mined, schedule-based	Stay long-term						Funding Tokens
									Consensus tokens
									Work tokens
									Asset Token
									Payment Token
									Voting Token

Table 1 - Morphological Box

5 Census analysis

In the current section, a census analysis is conducted in order to thoroughly answer the research questions and explore the use of tokens in business applications.

Please, bear in mind that some expedients were taken to avoid misinformation that could have biased results and data integrity.

- Discontinued or dropped projects have been taken out from the dataset.
- In the case of projects whose state of advancement has changed over time and information about them was available, the information entered has been updated accordingly.
- If more news related to the same project were present, only the most recent one has been considered.

After having taken these steps, the overall number of cases has been narrowed down from 176 to 151.

5.1 Overview

The research of the Observatory blockchain and distributed ledger technologies related to the analysis of projects and use cases of blockchain technology began in 2016. To date (November 2021) the news finalized and extrapolated are 151. The methodology used is described in paragraph 3.

5.2 Projects diffusion worldwide

Inspecting the overall number of projects what it can be noticed is an upward leap towards the adoption of tokens to govern public and private companies' business models. From the year 2016, in which just one single project could be retrieved, to our days, year that could count on 81 different projects, it is evident how such interest is rapidly growing and expanding. As appreciated from the chart below, the trend observed corroborates the increasing curiosity from incumbents to embrace the usage of tokens based on DLT with the purpose of creating a "parallel" incentive economy. As we can see, if we compare the growth with respect to 2017, a massive +1925 % is witnessed. The increase has been steady until 2018, with marked upsurge from 2018 to 2019 - +225% - and from 2020 to year 2021, +153 %. It can be further noticed that the growth from 2019 to year 2020 (+19%) has been slowed down due to the economy stagnation forced by Covid-19 pandemic.

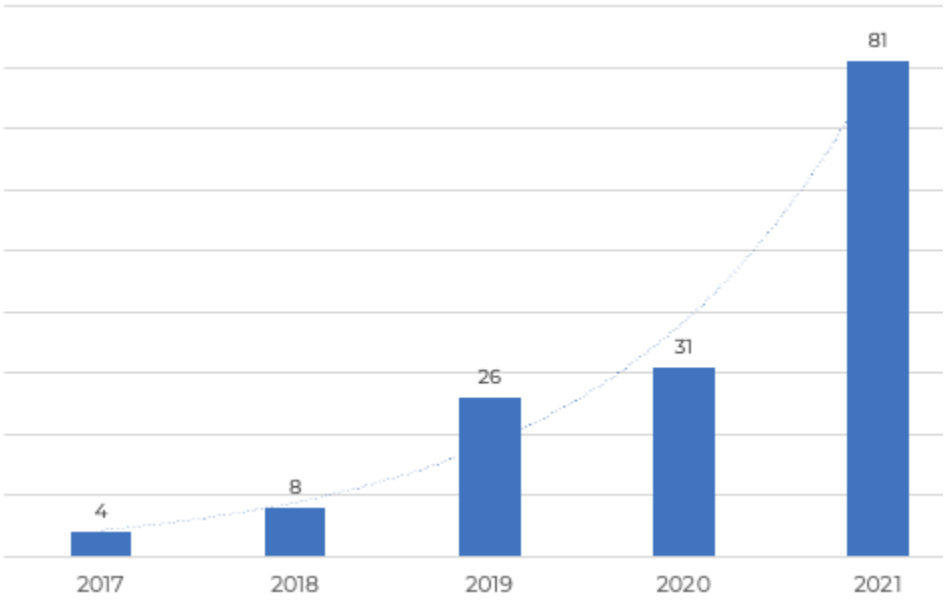

Chart 2 - Number of DLT token-based projects from 2017 to 2021 (cases n150)

However, the analysis as per above might be deviated by the actual research period, as the total number of cases analyzed in the last year stops at the beginning of October, 2021. Thus, it could be curious to investigate the growth of the first ten months, on a year-to-year basis in order not to bias results.

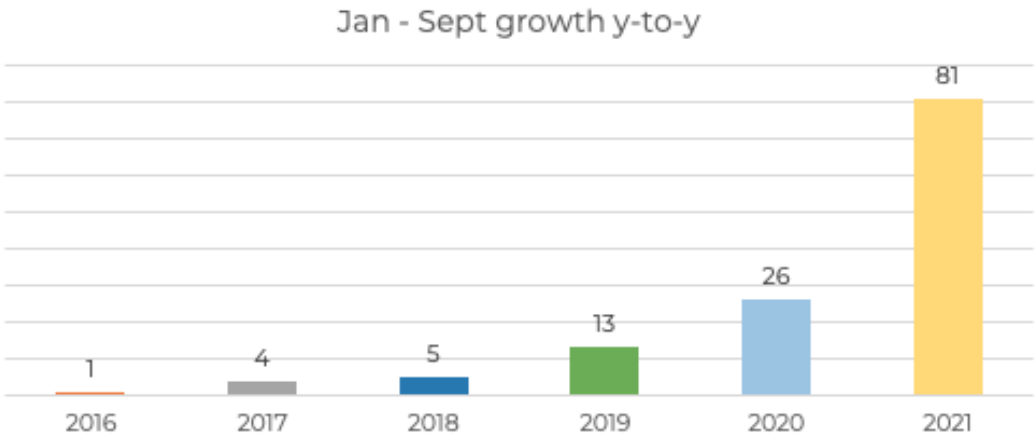

Chart 3 - Number of projects from January to September on a year-to-year basis (cases n.130)

What it can be observed is that exactly a half of the projects announced or in phase of development in 2019 began in the last quarter. After such normalization, the growth exhibited during 2021 is even more impressive: + 523% from 2019 and +212% from 2020. Even if data is not backed by any statistical analysis, it seems that 2020 growth curbed. The reason for this limited increase, still a clean +100 % with respect to 2019, is probably due to the Covid-19 pandemic that slowed down the development of projects already ongoing. It is interesting to note, however, contrarily to what expected, that the global emergency situation has only partially compelled incumbents to intervene across those

sectors that were most disrupted and jeopardized by the pandemic itself such as supply chain or healthcare, at least in a direct way. In other words, a more sustained growth has been witnessed in Governmental and Finance sectors mainly to speed up the distribution of financial aid to citizens and small-and-medium enterprises. Steep surge came about also in the Art and Entertainment sector. In fact, as stadiums around the world forced closure because of the social distancing compelled by the pandemic, clubs in precarious financial condition had to find new ways to engage their fan base and at the same time create an alternative profitable source of revenue. Other pioneering initiatives were targeted to strengthen the struggling restaurant and air travel industry as well as more generally the tourism sector industry through innovative loyalty systems.

5.3 Geographical distribution

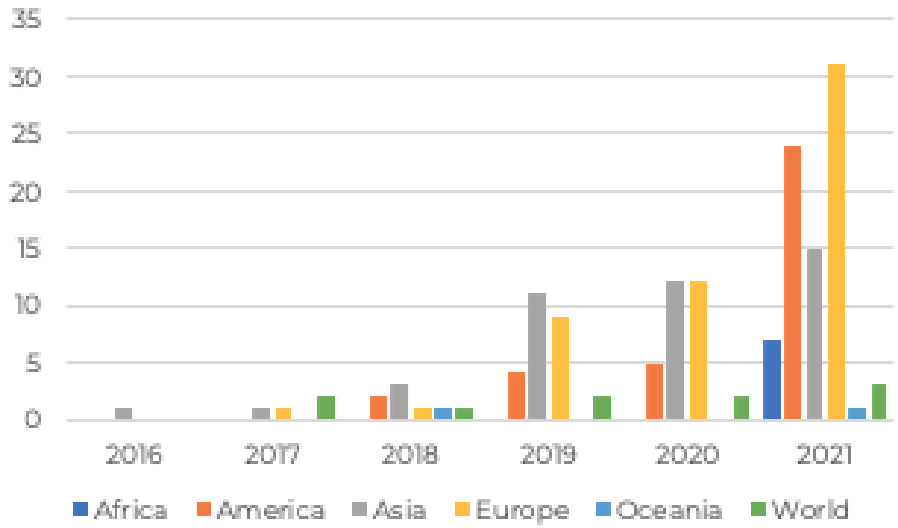

Chart 4 - Number of projects per continent year-to-year (cases n. 151)

Since the start of the analysis, neglecting the year 2016, Asia, being one of the pioneering and more inclined countries to approach digital transformation, have been a step ahead of other countries since 2018. America and Europe lagged behind but eventually managed to outperform eastern countries. In particular, token adoption in Europe underwent a breakthrough from 2018. In fact, from 2018 to 2019, a +800% was registered and the trend kept growing: in fact, until 2021, a medium growth rate of 50% was kept - +158% from 12 in 2020 to 31 in 2021. Overall, Eurozone has now become the most active in the field, summating over 30 projects. These figures are partly driven by fairly favorable jurisdictions like Germany (6) and Switzerland (8), this latter defined as the "Crypto Valley" of blockchain and DLT technology in Europe (The Cryptonomist, 2020). Nevertheless, there is no shortage of "more conservative" countries in this domain such as United Kingdom (12) and Italy (10). Similar considerations can be done for the United

States and Latin America, which experienced a steadier growth compared to the others during these years (+36% medium growth rate)until 2021, year that saw a sharper intensification of blockchain related programs – 24 projects overall, nearly five the times more. However, legally speaking, the western continent has had to suffer the revolt of the SEC in the context of ICOs bubble, which has left a trail and deferred the growth of the following projects. Africa deserves separate considerations. The developing country is shortening the gap only since the current year - mostly driven by governmental initiatives aimed at testing different typologies of CBDCs, 72% of the projects (5/7) - signaling how these themes are becoming much more mainstream, especially in a country that has long struggled with financial and infrastructural issues that could really benefit from adoption of this relatively new technology.

Below, a snapshot of the current scenario is presented. Please, pay attention that:

- the nationality of the project was taken into account and not the geographical area where the platform is operational.
- projects born from the collaboration of different countries have been grouped under "World".

Figure XX - Number of projects split per continent in 2021 (cases n.81)

5.4 Industries

In the chart below, it is shown the projects' distribution in percentage across sectors on a year-to-year basis. Clearly, as time goes by, the number of sectors touched by the

introduction of blockchain token-centric initiatives gradually escalate. As already mentioned in the methodology, the Eurostat NACE Rev2 and the CIS – Crypto Index Series- classifications were taken as reference to label the different sectors.

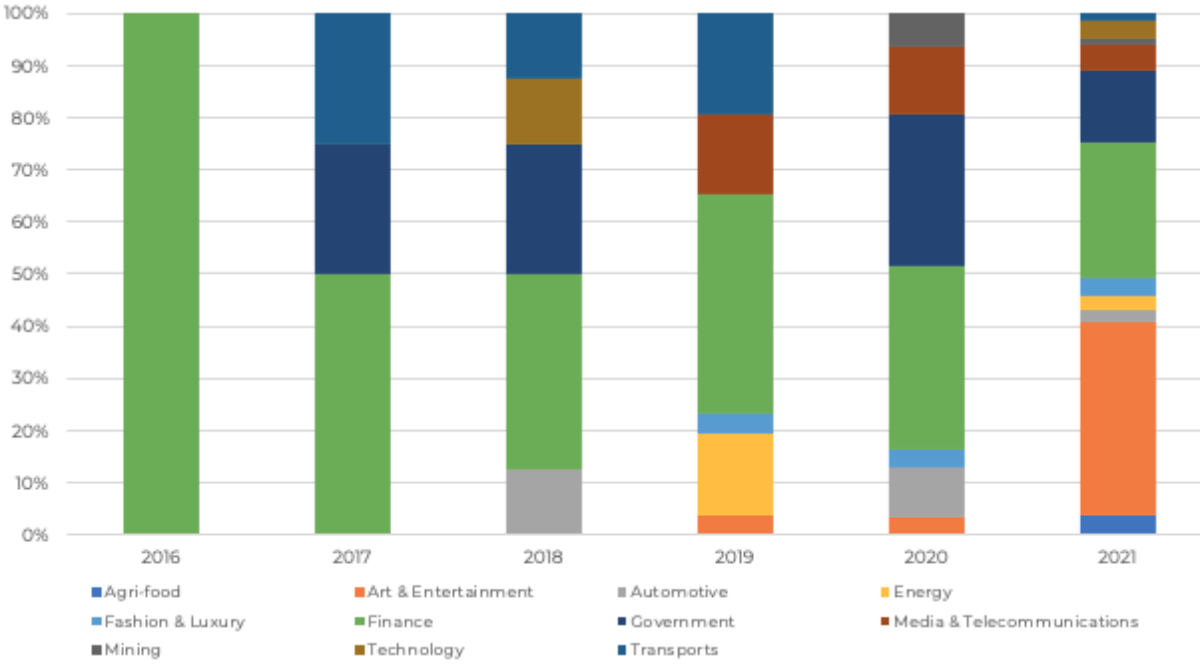

Chart 5 - Sectors' distribution (cases n.151)

It is interesting to notice that the number of initiatives belonging to the financial sector has maintained – relative to the total – more or less constant over the years - excluding 2016. Until recently, the use of tokens had been by nature an innovation adopted mostly in the financial field, so much so that it has always maintained a dominant position. In 2017, it accounted for the 50% of the total, percentage that fell to 37,5% in 2018 to rise again in 2019, 42%. Nevertheless, from 2020 the percentage fell of 7% and it further shrinked to 26% in 2021, but the number of absolute projects has grown, showing how this result can be explained rather by the astonishing growth of the other areas, to which it was never thought possible to associate tokens adoption. One of them is Art and Entertainment, whose number of news increased from 1 to 30 – accounting for the 37% of the total projects in 2021. 17/30 – i.e., around 57% - are initiatives of clubs belonging to different sports federations who decided to bring their fan base closer to the team through digital assets that provide holders with voting rights in binding decisions, prizes, exclusive VIP promotions, games and competitions. Such trend was initiated by the FC Barcelona club, whose sale of tokens soon after 2 hours from the launch amounted to € 1.3 million (Coindesk, 2020). Moreover, among the areas in gradual expansion from 2019 lie the Luxury sector, 3,7% in 2021, whose incumbents are introducing tokenized versions of their products to make them a wearable for that users' "avatars" can own inside virtual games or trade. That's the case of Burberry's partnership with Mythical Games or Nike's recently patented system named "Crypto Kicks". Not only, Nike aims at employing this system to ensure authenticity of physical goods and guarantee truthful provenance records for the sneakers in circulation. Recently, 4K, a novel marketplace that issues NFTs paired with luxury items held in storage to be used to earn yields in the DeFi realm, has

raised $3 million in a funding seed round. Other areas of development are Agri-food (3.7%) and Technology (3,7%) which despite the discrete portion of projects, have grown in absolute values from 2016.
Media & Telecommunication accounts for nearly 5% of the total projects even if, looking at absolute values, it stopped expanding since 2019, as witnessable by the chart above.

Overall, by looking at the chart below, Finance and Governmental sectors have been paving the way for leading the digital asset transformation and have just recently – in 2021 – been surpassed by the flourishing sector of Art & Entertainment.

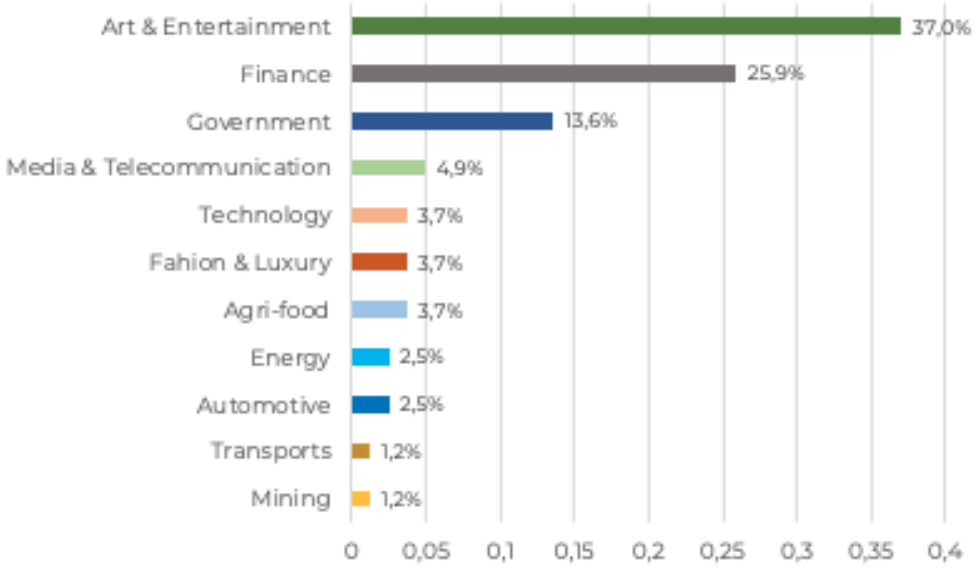

Chart 6 - Sectors' distribution in year 2021 (cases n.151)

5.5 Processes impacted

In this chapter we try to answer the first research question -RQ1 - of the paper: "What are the business processes most impacted by tokens?" This question has the goal to describe what are the processes most impacted by tokens adoption, explain how companies are deciding to integrate digital assets in their business models, and what are the benefits they could get.

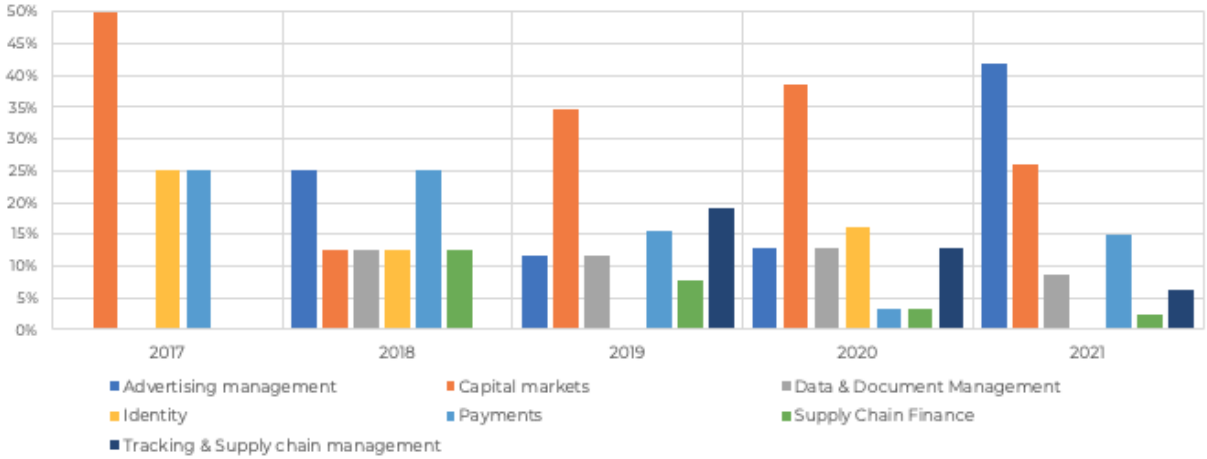

Chart 7 - Impacted Processes (cases n.150)

At a first glance, it appears evident the predominance of Advertising Management (beyond 40%, 34/81), Capital Markets (26%, 21/81) and Payments (15%, 12/81) considering the year 2021 (until October). Although Data and Document Management is placed a bit behind – accounting almost for the 10% of the total -, in terms of absolute values the number of projects related to the maintenance of a shared ledger to store valuable documents accessible through tokens is gradually increasing. Payment underwent a slight decrease during 2020, overcome by Identity (16%), Data and Document Management (13%) and Tracking and Supply Chain Management (13%) related activities of 2020 projects (32) - to eventually soar again during this year. In fact, besides Payments, if we look at the growth rate since the spread of the pandemic, what is blinding is the steep upsurge in Advertising Management-related activities, which can be explained by the mainstream explosion of NFT's marketplaces and Web 3.0 decentralized applications attracting customers in fun and exciting initiatives, and Capital markets
The same reasoning cannot be made for Tracking and Supply Chain Management, as growth never completely recovered and currently standing at the same height as 2019, 6,2%.

By crossing the results obtained from the two previous analyses, it is noteworthy to underline how Payment, which was basically on of the main purposes of the introduction of the technology, account for less than half of use cases in the Finance industry, where instead most of projects refer to Capital Markets – i.e., digital securities tokenized and launched in primary or secondary markets.
Data and Document Management-related projects based the exchange and recording of contracts and information through the usage of tokenized assets are becoming ones of the most dynamic and cross-cutting areas of applications, from 3 in 2019 to 7 different sectors in 2021, + 133,3%. The same thing can be said for Advertising Management's related applications -but in a less pronounced way than Data and Document Management - due to a much more standardized approach that companies can take on and pursue by exploiting their popularity and their proximity to a sound customer base, i.e., loyalty and fan engagement programs.

To recap, below are listed the most impacted processes in token adoption:

- Advertising Management
- Capital Markets
- Payments

The above considerations can be also confirmed by the following analysis which compares Sector and Process Impacted. As we can appreciate from the chart below, token applications but Advertising management are more routed towards precise sectors -let's think of Capital Market and Payments. This might be due to the fact finding the best suited token-centric business model in contexts like Tracking and Supply Chain Management or Supply Chain Finance is more arduous, challenging and requires more actors involved. Despite it, by merging the data from Chart 2 and 3, it is possible to witness how this tendency is likely to disappear. For instance, zooming in to Tracking and Supply Chain Management, it is observable how in the current year, despite the overall projects being less than in 2019, they are more diversified than past use cases. A similar reasoning can be held for Data and Document Management as a growing number of companies running in different industries are finding a shared ledger regulated by a utility token a very appealing alternative.

The following section explores the processes that have not been touched along the final chapter, where the findings just outlined in the Executive Summary will be discussed, as these are not so spread amongst the use cases encountered but still growing. A qualitative description over how tokens are used in each context and potential benefits is provided

5.5.1 Data and Document Management

As previously anticipated, Data and Document Management-related solutions are experiencing a surge as companies find useful to establish a secure, decentralized and truthful ledger where to store and track their digitized documents, whether being patents, land properties or other kinds of ownership certificates. The data management process is critical to guarantee secure access to reliable, verifiable data to enhance and improve fast-taking business decisions. The decentralized nature of these networks solves the issue of the singularity of point of failure to which current centralized systems are exposed to. Blockchain offers a true sense of bringing trust factors in the data through cross-checking, encryption, digital signature and immutability.

The following sections present some of the use cases encountered and applied directly in such domain.

Amongst the cases observed, 27% (4/15) refer to scarce digital collectibles – art - offered in auction the proceeds of which provide the user with a verifiable proof of donation, i.e., charities, for tax purposes, 20% (3/15) are tokenizing both the legal ownership related to an existing asset and the digital representation of the asset itself – of which luxury item (2 cases) and property (1 case) – that can be traded and their legal authenticity be easily

proved enabling the bearer to eventually take on loans and use them as collateral for borrowers in DeFi applications.

Other use cases, 27% (4/15), deal with paper certificates put "on-chain" such as deeds, patents, warranties, and bank sureties – all having a validity date after which expire but tradeable, except for warranties. By providing an accessible and transparent record-keeping platform, the blockchain system can capture the necessary updates and record them automatically when any transaction occurs (license, purchase, or sale), making the process way more cost-efficient – also in terms of budgeting. Moreover, this makes room for improved real-time data analysis through smart contract interaction, giving edge for organizations to improve their back-office activities. Nevertheless, the asset represented by the token could be manipulated off-chain without recording changes on the blockchain, thus compromising integrity. In latter use cases it is not clear if tokens are directly surrogate of asset ownership or are used a mean to access the intangible fixed assets and manage their ownership – identification – on chain. In fact, it is noticeable that these initiatives take place in private permissioned or even hybrid networks– to avoid disclosure of sensible information beyond the involved parties. Only one use case concerning land registry with legal deeds is hosted in public network as citizens must be able to consult it at any time.

Remaining 27% (4/15) of the initiatives expect users to share usage data about a product or public service offered by a private manufacturer or municipality respectively – by inputting them manually through a web app at a later time or in real time for IoT appliances- in exchange for tokens that can only be redeemed on certain marketplaces. The main goal of these applications for issuers lies in getting precious information about consumption behaviors and habits that they can share in turn with its suppliers or keep to themselves to improve the services they are offering. However, in those mechanisms which do not imply sharing in real time contextually to usage, data might be inconsistent.

5.5.2 Tracking and Supply Chain Management

For sure, amongst the processes with the highest potential to grow is that of Tracking and Supply Chain Management. Supply chains across different industries involve a myriad of actors and intermediaries, are complexly intertwined and end-consumers are becoming pickier on what they are being offered, while demanding for lower costs. Moreover, the crisis has forced many to reassess their supply chains, experiencing pressure to increase domestic production is urging and at the same time rethink strategies based on lean approaches and just-in-time replenishment, with dire consequences. In this context, not only blockchain-based ecosystems can call for greater efficiency and cost reduction, but at the same time replace paper-intensive practices that lead to errors, delays, directly impacting on costs. The use of blockchain provides not just a unified source of data to draw from in a secure and transparent way but designing a token at the core of such ecosystems enables to onboard and align different participants and make sure that they act according to a precise system of incentives and in the best interest of the platform.

A 2020 EY report on the pandemic aftermaths in supply chain highlighted how companies are seeking to build resilient, collaborative networks to connect with customers, suppliers, and other stakeholders, claiming how supply chain visibility will become the number one priority over the next three years. A token incentive-based model built on blockchain-based platform can provide a unified, decentralized network that potentially rewards who provides updated real-time information on product location and history, that help to solve disputes, improve coordination, and that preventively signal any facing problem can be the key to meet the challenges discussed as per above. Moreover, a decentralized shared network structure removes the need to maintain outdated legacy incompatible IT systems, mostly unable to communicate and behind one of the few causes of rising costs.

The most frequent use cases are bounded to the Energy and Media & Telecommunications industries, 5/14, 36% each; in the former industry, solutions introduced are aimed at creating connected locally-oriented smart grids to exchange renewable energy certificates in the form of tokens and allow consumers to take part in the process, becoming "prosumers" contributing directly to the grid – solving the issue of energy storage – and at the same time be sure of which energy utilities and producers are exactly buying and where does it come from. Besides transparency in the sourcing process, an advantage is given by the possibility to fractionalize these credits, which are not sold in bulk and allow a 1:1 relation between the energy generated, equivalent to a precise amount (1 MWH generally) and its tokenized form. If on the one side consumers can become new distributors and reinvent their role, disrupting and streamlining the traditional energy supply chain, energy suppliers can trade these tokenized certificates at lower costs and greater efficiency, eliminating intermediaries and establishing long-term relationships with the local-based community. Once the power provider has fed the energy into the grid, the REC received can then be sold for profit on the open local market as an energy commodity to those looking to offset their carbon emissions and that must stick to ESG reporting requirements. In a joint study back in 2020, the Sustainable Digital Finance Alliance (SDFA) and HSBC Center of Sustainable Finance highlighted how green bonds can reduce management costs and increase operational efficiency by up to x10 times.

One use case sees the token being a cryptocurrency given as a reward for recharging at lower speed to benefit from whenever a shortage of electricity occurs, which is spendable to pay the bill or other necessities and bound to electric vehicle chargers, always at a local level.

For what concerns Media & Telecommunications, use cases are implemented to provide a verifiable source of online shared content or network resources for those in need in lesser developed countries to steer local communities. One initiative, for instance, see content creators and distribution rights' owners tracking the circulation of multimedial content on their broadcasting platforms through tokens, empowering end-users by licensing them the right to modify it or share them. This ultimately enables distributors to cut their costs and at the same time provide enthusiasts with a source of revenue and a legal instrument which does not represent a copyright violation.

5.5.3 Identity management

Identity management is one of the other growing trends in blockchain, even if not supported by the dataset as projects impacting on such domain dropped to zero after 2020. Nowadays, the reliance upon service providers model for digital identities - as a consequence of the directive on GDPR in UE - seems not to have entirely solved issues like interoperability, inaccessibility and sensible data leakages and present in disparate sectors such as healthcare, banking, education and governmental, even if it represents a step towards less fraudulent identities.

A distributed registry based on blockchain enables citizens and users to possess the same source of truth concerning who validated that info, if they are valid and directly relatable to the owner, without the need to expose or exhibit them to those in charge nor to save personal data on the distributed registry.

Identity management on blockchain introduces a new concept namely "Decentralized Digital Identity" or DID. In contrast to typical identifiers such as passports or driving license, DIDs have been designed not to rely on a central intermediary, i.e., identity providers, and can be assigned to anyone being it a person, organization or object (cars, etc.…). DIDs can operate across different blockchains and let the user have complete control over their identity and data, reestablishing accountability and power.

DIDs can have plenty of applications such as in DAOs – to reward members' contributions more accurately instead of "whales", i.e., big players owning large amount of tokens -, NFTs – to verify the creator and the collector of any digital artwork - and DeFi – credit evaluation mechanisms based on reputations' systems to democratize financial systems access.

The concept of DIDs is at the core of Self Sovereign Identity (SSI) systems to allow people online to act with the same degree of freedom and trust as if they do in real-world life, owning their personal data and sharing with who they like.

Identity related activities come entirely from public and governmental initiatives -as they are the ones issuing our IDs - aimed at giving back ownership of users' personal information, overcoming hurdles connected to the traditional centralized storage and third-party Identity Providers, by offering a peer-to-peer system in which users can store encrypted and separately verifiable claims without any single points of failure.

According to the projects analyzed, however, 4/7 are tied to government-allocated aid to war and pandemic-affected areas whose identity verification is preliminary to access the funds. Blockchain is instead used to manage the transfer of tokenized funds, conditionally regulated by smart contracts which are attached to the tokens and ensure they are not misspent.

The remaining cases observed are based on the implementation of a blockchain-based identification system but in which tokens are used for different or as yet unspecified purposes. While in one use case tokens are being offered as a reward to people who

participate in the registration process and use their blockchain-based ID to access a service, in the others it is not sure how tokens will be attached to the decentralized identity. Generally, they consist of utility tokens used for the tagging of cryptographic blocks with the unique owner's identifying code.

5.6 Protocols used

In this section, an analysis of which are the most employed types of blockchain platforms when it comes to tokens adoption is unfolded, by combining the two main attributes that define four main platforms categories.

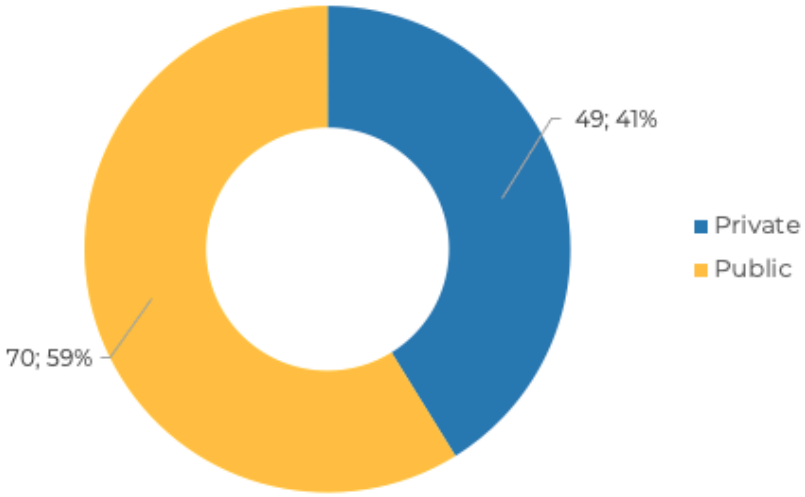

Chart 8 - Private vs Public platforms (cases n.119, no data are excluded)

The first thing to underscore is that public blockchains (59%) are much spread out if compared to private ones (41%), as far as access to data and participation into the network are concerned. Such figure can be explained by the fact that plenty of times tokens act as incentive-aligning instruments in environments where anybody is allowed to onboard – open-access networks - and perform transactions with another party. Somehow, there are cases where platform behaviors are already regulated by network participants' agreements, hence, a token to regulate them might not always be necessary - unless a practical meaning is extent.

Also, as displayed below, it is as interesting as reasonable to note how private platforms – thus, permissioned - slightly prevail when it comes to pilot testing or research environments – respectively 52% and 51% - showing how companies privilege track the identities of the participants so that they can decide autonomously to whom entrust the validation procedure. However, when it comes to live projects, companies prefer to opt for public platforms (63% of the cases) in order to raise the potential reach.

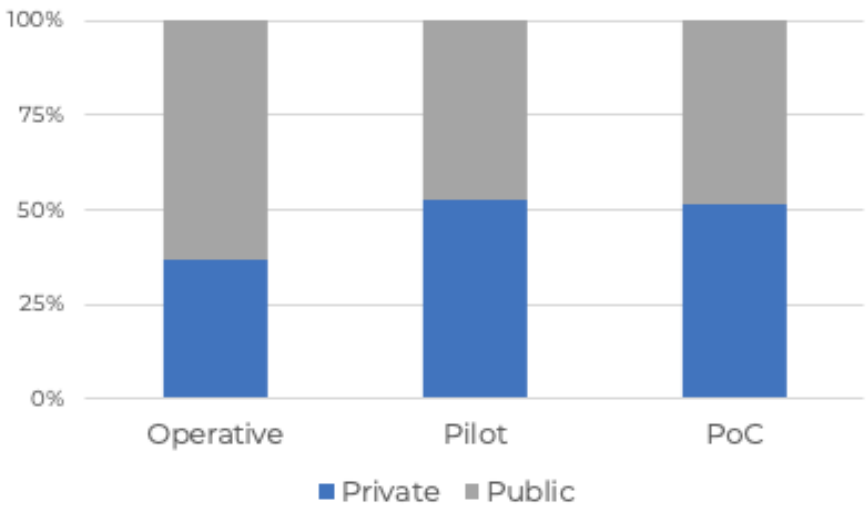

Chart 9 - Platforms employed per stage of development (cases n.96, no data and announcements excluded)

Besides "no data", 40% of which belongs to initial stage projects, "announcements" have not been contemplated as 38% (14/37) of initial stage projects did not disclose - probably because technical details are not yet known – any information about which type of platform they will be using, a percentage that drops dramatically when advancing onto the next phases of development. Moreover, even if in principle they do know it, anything might easily change along the way and it could happen that the platform they've identified at the beginning might not refer to the final deployment solution once project would be fully operative.

By intertwining the results as per above with the correspondent validation mechanism used by the different types of ledgers, thus combining the two main variables employed to categorize platforms, it is possible to obtain the following chart.

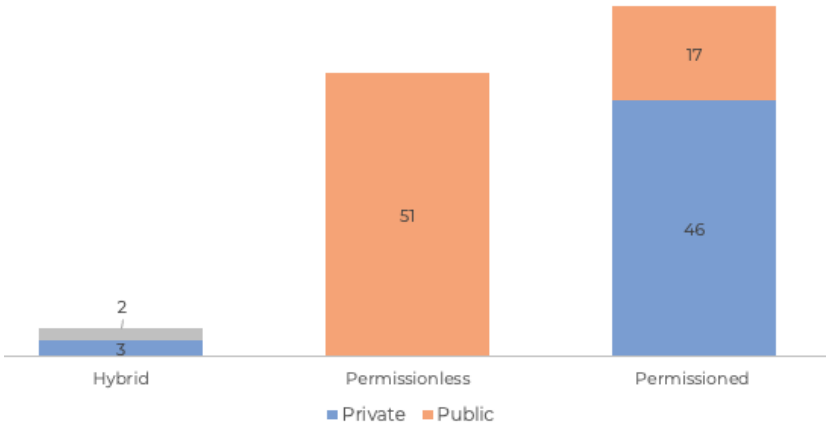

Chart 10 - Ledgers' Typologies according to the two main variables (cases n.119, no data are excluded)

It shows a marginally greater diffusion of permissioned platforms (53% of the total) over the whole period studied – whether being private (46) or public (17). Likewise, if when referring to the y-to-y figures, the number of permissioned and permissionless ledgers almost grew with the same pace and they "sorted the cake" in nearly equal pieces, except for the 2020, in which projects based on permissioned platforms outpaced by double permissionless ones. It is worth remarking how the development of "public permissioned" platforms goes just back to the current period: in fact, 71% of the projects initiated using this kind of platform relate to the year 2021. For many years, associating these two words was considered an oxymoron and a misnomer. Just recently companies have begun to appreciate the benefits coming from this somehow mixed network bringing together the permissioning features with an inclusive decentralized governance model.

5.7 Platforms distribution

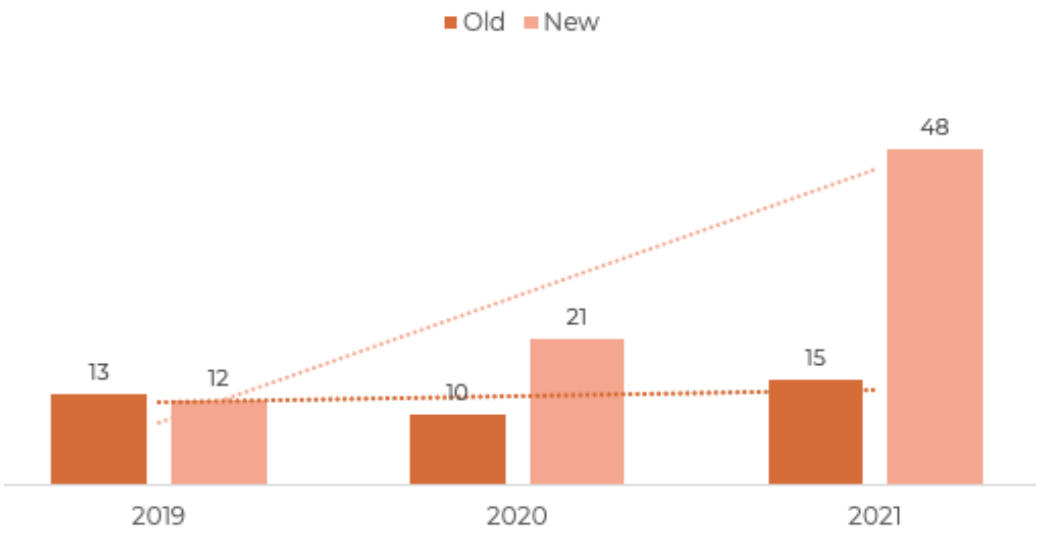

Chart 11 - New vs Old DLT-based platforms (cases n. 119, no data is not considered)

The chart illustrates how companies are more eager to shape ad-hoc platform from scratch, harnessing existing production-ready frameworks and SDKs offered by well-established actors in blockchain and DLT-based sphere infrastructures– the main ones in being Hyperledger solutions (22%, 10/45), Ethereum for Enterprise (22%, 10/45), R3's Corda (nearly 13%, 6/45) for permissioned private environments. These are few names that have built-in blockchain frameworks allowing enterprises to develop and host applications on the blockchain.

In fact, by examining the protocol layer on which such platforms are built, more than 97% count on existing DLT-infrastructure – i.e., 116 out of 119 projects (projects with no data are excluded). Building a protocol from scratch involves expertise and know-how, both

private and public companies seem to remain trustful to the use of consolidated protocols.

Below, a snapshot of the most common platforms is presented.

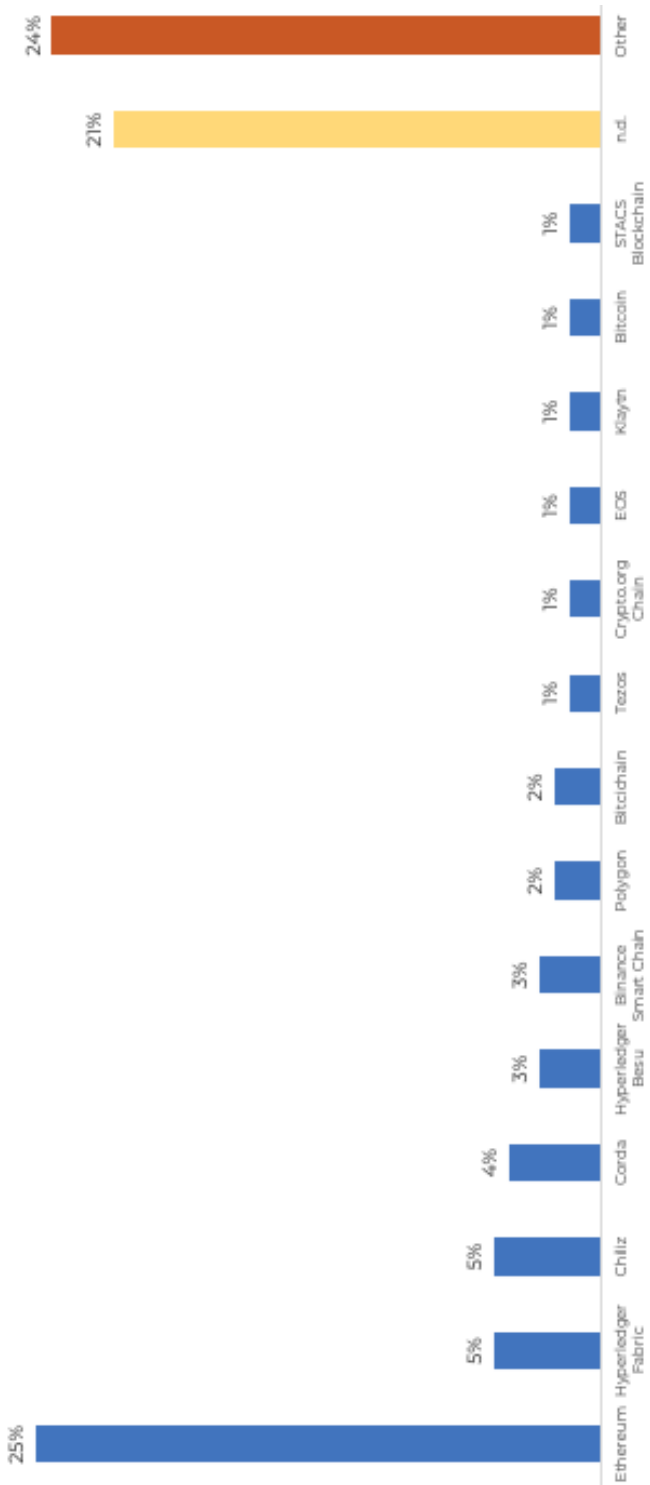

Chart 12 - Platforms' Diffusion (cases n.151, in "Other" they have been grouped all those platforms popping up just once)

As a matter of fact, the degree of modularity that these ready-to-use kits offer is wide, with plenty of opportunities to create tailored solutions according to the needs.

To date, more than 76% of newborn current blockchain projects decides to develop proprietary blockchain-based platform compared to less than 24% of "old" platforms. Clearly, this reversal trend started after 2019, in which instead a slight majority of platforms (52%) were already existent – and likewise in 2017 and 2018. If considering the whole period 2019- present– number of cases counting on "new" platforms underwent a massive upsurge of +300%. On the contrary, still by looking at the time series, the trend relative to the number of projects built on existing platforms has remained almost steady (just 29,5% of the total time assessed), demonstrating how companies are slowly shifting away from these solutions and from time to time more interested in owning the mean through which they offer their services or goods.

5.8 Token Archetypes & Descriptive cards

In the current paragraph, the archetypes introduced in the census description will be described by providing a real use case as an example for each of them to figure out how they work, make their usage more down-to-earth and how such tokens behave in real-world applications. For each archetype, a descriptive card of the project of reference is provided with the aim to summarize their main features. Please note that the selection of the archetypes to describe and depict are taken with the aim to make coexist two or more features embedded in the same token's functionalities, rather than picking a token that could exhibit just one purpose.

Obortech - The Smart Logistics Hub – Work Token

Obortech was founded in 2019 to respond to a fragmented and obfuscated supply chain, choked by limited and unfair market access, lack of visibility giving rise to disputes and unexpected risks, siloed and outdated legacy systems and intensive paper-based, time-consuming processes. The World Economic Forum estimates that document processing accounts for 20% of the total transportation costs within global trade. According to TradeLens's study, nearly two thirds of shippers say that visibility was the most needed IT capability of their 3PL partner in 2018. In the complexity of food supply chains, such issues are even more exacerbated. As fresh food purchases have gradually outpaced other food consumption, transportation remains an issue. According to IBM Food Trust available statistics, USD 7 billion worth of fresh food still spoils before ever reaching a consumer in North America alone. The IFIC (International Food Information Council) estimates almost 60% as the people who care about food to be produced in a sustainable way and reflected also by a PWC report claiming that 32% of consumers are willing to pay a premium if the know the origin of a product and manufacturing methods. Moreover, food fraud is a global market worth $ 10 billion, with cargo theft exceeding $ 25 billion worldwide (BSI Group's Global Supply Chain Intelligence Report, 2015).

Obortech aims at addressing these issues with an integrated information ecosystem including unified communication, real-time tracking and analytics and greater shipment visibility by way of four components:

- Blockchain and cloud-powered communication hub with user-friendly interfaces and open access APIs.
- Tamper-proof, unified and online document exchange allowing authorized parties to see whether changes have been made and by whom along a shipment journey. Any change is recorded on the blockchain and must be endorsed by the network participants.
- IoT based real-time visibility through sensors that transmit data related to critical conditioning control – e.g., temperature, humidity, container opening - and tracking to protect high-value products against theft.
- Open decentralized marketplace enabling automated rating and performance valuation of all the stakeholders in the supply chain with no need of third-party credentials and all managed by smart contracts. Buyers and suppliers would thus make informed decisions when exchanging – i.e., buying and selling – products and services. This is the stage where the tokenized economy unfolds.

The Smart hub platform is comprised of Private Hyperledger Fabric Blockchain & Ethereum Public Blockchain. Supply Chain & Marketplace DApps are built with Hyperledger Fabric, whereas Ethereum is used for tokenomics and processing token payments. There can be different supply chain networks. Members of the same business supply chain can work together and are destined Channels to keep data private. Members themselves are the governing bodies of the network so that any new member joining the system must be approved. Obortech uses a partner-driven approach in each supply chain – i.e., consortium blockchain -, and so an "anchor" will be selected based on who led the creation of the supply chain network to bring in new partners and benefit from a revenue sharing-model.

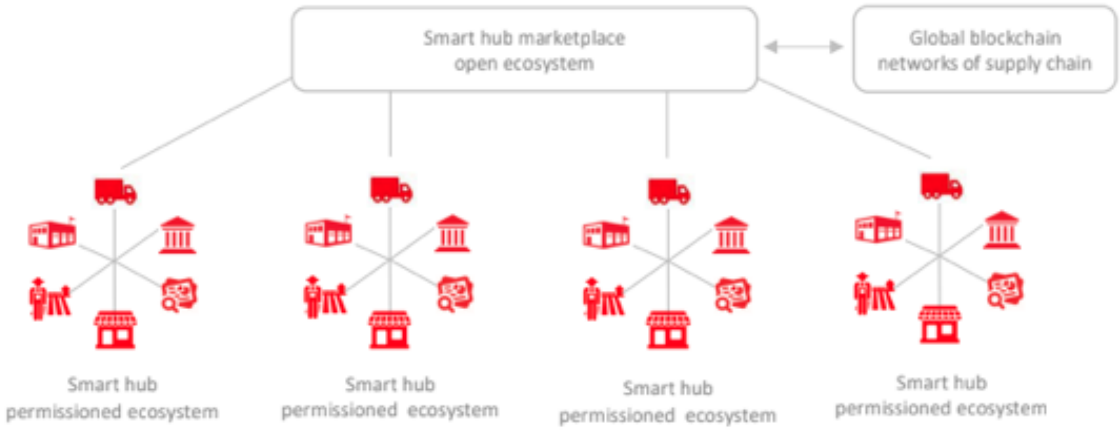

Figure XXI - Obortech's Ecosystem

The Smart hub will not replace existing systems of regulators and institutions engaged transport and logistics. Instead, it will provide a platform underpinned by smart technologies for smooth and efficient integration. Obortech works with a transaction-fee model and participants are charged any time data on each container or shipment is exchanged amongst (paid) users - i.e., exporters/ sellers/ producers, importers/buyers/merchants, transporters/3PLs, insurance firms, and financial institutions -, as a result of the four main "bundled" services provided to the network and described above. End users and regulators will have free access to the Smart Hub.

Transaction fees are paid in in the OBOT token, that is the pulsating heart powering the Smart Hub platform and which have also other main functionalities:

- Contract bonus. Users collaborating via the platform can convert some portions of their contract funding into OBOT tokens to be allocated in Escrow Contract as a bonus payment, released after meeting certain extra conditions included in the Smart contract.
- Exchange services in the marketplace such as reports, truck repair, navigation help, IoT sensors fix, etc.… All these functions will be regulated by smart contracts.
- Reward based on the member score/rating in the marketplace impacted by performance histories, active participation, response rate on document exchange activities and satisfied client reviews. Likewise, poor performances will be penalized through downgrades of the members' score.
- Crowdfunding. Members can challenge crowdfunding initiatives to their partners or costumers either by lending with interest rate computed on ratings or by pledging based on escrow contracts between creators and backers.
- Governance. OBOT holders are entitled to participate in or delegate the governance decisions of the marketplace such as members enrollment, service exchanges, and crowdfunding activity policies.

Transaction fees are destined for the 70% to Obortech Global – parent company - in the guise of network administrator whilst 5 % is used for buying backs and token burns to increase investor trust. Remaining percentage is addressed to community building and new user growth pool.

OBORTECH

Mission:

Create a decentralized ecosystem that uses DLT and IoT to allow players in a supply chain to communicate and track high-value shipments in real time.

Details:

Status: Operative

Year: 2019 - in progress

Focus: Work, Payment and Voting Token

Area:

Description:

- In May 2019, the project concept was formalized and by the end of 2020 the prototype was tested on one of Mongolia's biggest meat exporters' inland export shipment to China.
- The token sale to early investors and the Intial Exchange Offering took place at the beginning of 2021 while the Smart Hub is operative from the second half of 2021. The open marketplace is expected to be launched at the end of 2022.
- As of November 2021, the project has two companies: OBORTECHglobal OÜ in Estonia and OBORTECH Mongolia LLC in Mongolia. The company has established partnerships also in the Netherlands and Australia.
- Its goal is to serve 5 % of inland transportation of selected perishable products between Europe and Asia, and intra-Europe by 2025.

Platform:

Obortech - Smart Logistics Hub

Protocol:

- Hyperledger Fabric
- Ethereum

Partners:

- Intermodal Solutions Group, Alliance for Internet of Things Innovation, Government of Mongolia, Mongolian Express LLC and Mongolian Transport Corporation, Dutch Mongolian Trade Office, Ministry of Food, Agriculture and Light Industry of Mongolia.

Similar projects and competitors:

Currently, Obortech does not have any direct competitors being it the front-runner. Existing legacy "competitors" systems are:

- TradeLens
- Traxens
- DataPorts

Figure XXII - Obortech's Descriptive Card

Below, the OBOT token distribution is illustrated.

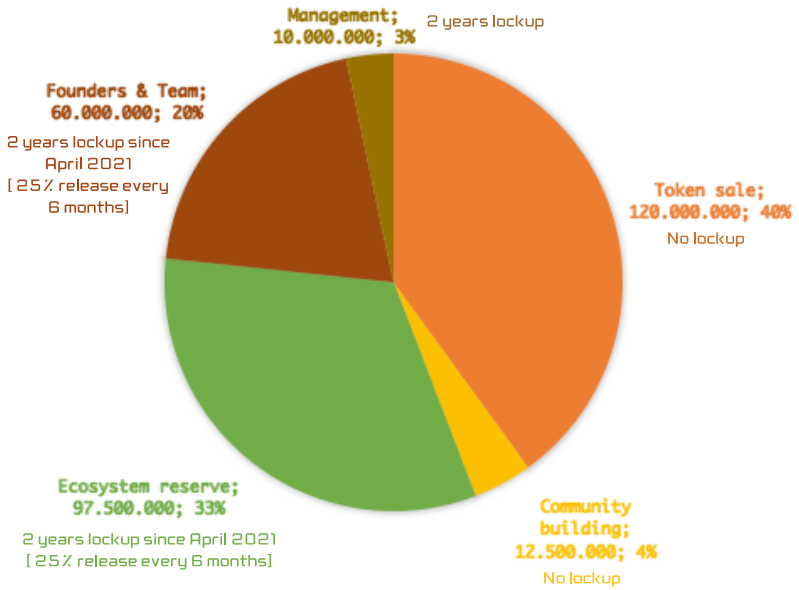

Chart 13 - OBOT token distribution. Max supply: 300.000.000

SSG.COM - Asset Token for traceability solutions

Together with environmentalism and sustainability, protecting brand authenticity has rapidly risen up the business agenda, as the Global Brand Counterfeiting Report projected losses of almost $100 billion when it comes to luxury goods. Not only, the latest diffusion of fast fashion, characterized by obscured supply chains, high pollutioned and environmentally unsustainable, has offered brands a new sophisticated way to show their customers how transparent they are, in terms of sourcing raw material and working conditions. This has become a mantra as a 2020 report conducted by IBM highlights how more than 70% of consumers *find moderately important that brands offer "clean" products, are sustainable and environmentally responsible (77 percent), support recycling (76 percent), or use natural ingredients (72 percent)."*

In this context, digital solutions based on blockchain found fertile ground to thwart counterfeiting menaces, allowing big brands to assert sustainable and ethical values and enhance their value proposition, differentiating amongst other competitors due to an improved user experience. Depending on the specific needs, a digital identity for each product is established, being it a "digital twin" regulated by a specific token (its digital twin, usually in the form of an NFT) on a blockchain to monitor its lifetime journey from raw materials to distribution, sale and resales. The blockchain technology enables the creation of a secure, immutable record of each item that is sold and changes ownership. Consumers in this way are sure that what they are buying is authentic, regardless the items come from a secondary-hand or directly from the retailers' ecommerce platform, without fueling the sunk market.

Recently, a south Korean e-commerce platform namely SSG.COM, the shopping outlet of retail giant Shinsegae, integrated a blockchain solution to issue warranties as non-fungible tokens for a line of 5000 products + 5000 about to come by the end of the year. The service dubbed "SSG Guarantee" allows consumers to download the digital certificate through the digital wallet Klip, from the messaging application KakaoTalk. It stores as their metadata information like the current owner, item's serial number, purchasing history, validity of the warranty and other information. The main goal of this project is to provide consumers with legitimate information about the authenticity of the goods they are buying.

This is just the latest of some of the solutions developed in the high fashion and luxury industry, like the one implemented by Breitling past year, Swiss luxury watchmaker that joined to the blockchain alliance Arianee, for the creation of a digital passport on-chain, and that is going to add up to the globally pioneering AURA consortium, founded by in 2019 by LVMH and joined by Cartier and Prada, in partnership with tech-companies ConsenSys and Microsoft, to track the authenticity and history of luxury goods.

Figure XXIII - SSG.COM's Descriptive Card

Play to Earn, the new NFT's gaming frontier

In the past decades, we have assisted to seismic changes in this industry, summed up in the image below. Currently, video gaming overall is an industry worth $ 170 billion, and it is projected to rise to nearly $ 270 billion within the next 5 years (CoinTelegraph, 2021), convinced that this increase may be driven by an innovative paradigm that is recently gaining traction in the gaming industry, the so-called play-to-earn model.

Figure XXIV - Business models' transition in the Video Game Industry

This loring type of gaming enabled by blockchain gets added to the already acclaimed and almost mature free-to-earn gaming market – running on centralized datacenters -, in

which players can download a game for free, but with limited experience. If they wanted to access extra-content, speed up their advancements or add up special features and accessories to their in-game, they would have to pay using in-game currencies. Over time, developers mastered the art of free-to-earn monetization and marketing to eventually outbid competitors. An example is Fortnite, the battle-royal multiplayer game completely free to join, that in 2019 totaled an astonishing $ 1.8 billion in digital sales, to remain No. 1 nearly 3 years after its release, overthrowing the likes of largest PC game "League of Legends" (CNN Business, 2020). Nevertheless, Epic Games – i.e., the Fortnite creators – is getting the "whole pie" as it has control over the items players buy using the in-game marketplace. In fact, in the "pre-blockchain" era, content was locked behind people' accounts and it was actually just a lease or licensing form with no trading capabilities to transfer or sell. On the other hand, the play to earn, although inheriting many similarities and mechanics of the above-mentioned business model, allow gamers to exert ownership over in-game digital assets, whose value can be actively increased by playing the game. This means that certain assets are owned by users' themselves and can be sold on any secondary platform outside the game universe (not compulsory through the platform marketplace). Moreover, players can collect rewards in the form of cryptocurrencies, valuable, limited-edition NFTs and other in-game resources with purely aesthetic functionalities or with a given utility - depending on the game played - that can be tokenized on the blockchain as NFTs that may eventually cash-out for fiat – just by playing games and have fun. Each game provides financial incentives to play and progress. The cost of acquisition will be much lower as once an income is provided to players, those players rush into it as a result of word of mouth. Players dictate and participate in the in-game economy, this brings value both to other users and developers, creating an additional incentive for same-side and cross-side network effects to flourish. Another aspect is related to psychology and the possibility not to see expenditure in-game as a mere leisure and waste of money. Instead, if spending gives players an opportunity to trade what they contributed to create, this is most likely seen as an investment opportunity. Below, a comparison of the two business models is presented from a system design perspective.

Figure XXV - Comparison between F2P and P2E pillars

The P2E is based on the same exact pillars of F2P, i.e., marketability – how much the cost of acquisition will be based on how appealing could the game be to the target customer segment and how big that segment is -, monetization – how likely users are willing to spend per purchase and how frequently they purchase, assuming that developers are able to keep player engaged, i.e., the amount of revenue generated -, and the retention rate – how likely users will come back playing and stick around. Alongside these, P2E adds up some more "columns":

- Economic sustainability. It measures users earning potential compared to the prices borne to access the game, thus its economy stability. This translates into a balanced expansionary/contractionary fiscal policy to maintain prices stable.
- Minting power. It indicates how much the game charges players, i.e., fees, to mint fresh new NFTs.
- Marketplace Trading Volume (MTV). It measures the trading volume amount that is moved through the marketplace. Requiring a fee for each transaction, the higher the volume or number of transactions, the higher the revenues. Along with minting power as per above, these two elements represent new avenues for developers to enhance monetization.
- Perceived Longevity. The investment players make in the game, thus prices and demand for the game today, are affected by the perception of how successful the game can be over time.

Play-to-earn showcases all the forthcoming potential of blockchain technology and is a game changer since it opens up to uncharted horizons where also ordinary people could take part and could actually make a living in a "parallel" universe, i.e., metaverse - a place beyond reality, completely digitized and fictional where people can literally dive through AR devices and spend time and resources at -, moving their unique avatars cross-chain from one metaverse to the other. However, this seems at the moment a difficult design task to accomplish and that could dilute the NFT in-game potential, without remining true to its essence.

Play to earn is considered the secret to mainstream NFT gaming adoption. Many developing countries around the world hit profoundly by the Covid-19 have become catalysts for such games, in which users can find an alternative stable side income. Amongst the most successful games we find Axie Infinity, the Sandbox and Decentraland – all three running on Ethereum. Essentially, a user may earn income in three different ways:

- Earning and trading in-game NFTs
- Earning and trading in-game currency
- Staking

Not all the play to earn games are free to join – each developer follows his own path - and an initial investment may be required. This is the case of Axie Infinity, for instance, which, as of October 2021, requires an initial investment of around $ 600 – 1 k to purchase three Axies NFTs and start playing (Binance Academy, 2021).

Burberry x Blankos Block Party – Playable Asset token

Blankos Block Party is a play-to-earn - freely accessible - multiplayer open-world game featuring digital vinyl toys also known as "Blankos" that live on the EOSIO private blockchain, providing players with a proof of verifiable ownership. Endless possibilities of what players can do in the game makes it one of the most ambitious in the landscape: people can explore, jump into games together, create new worlds or games and set them up according to their own rules, giving rise to highly customizable experiences.

The playable NFTS in Blankos Block Party are as useful as any character that might be played in any other game, but thanks to the technology behind, players can actually own what they buy and can sell them for real money when they don't want or need them anymore, unlocking the value of their monetary and time efforts

Blankos virtual toys can be purchased from drops, marketplace or can be earned for free just simply by playing the game through the Party Pass. These are seasonal passes that reward players as they play by completing daily, weekly and seasonal challenges, unlocking new accessories and special NFTs items. However, most items and consumables earned are not in the form of NFTs. The same happens for the Blankos people will receive when joining the game since everybody gets them. However, each Blanko comes with a unique set of skills. Blankos, besides coming in plenty of skins/ designs, are not much accessorizable and the only way to do so is to mash them up in "The Junction", i.e., a mashup station. Blankos avatars can be levelled up through daily quests or other game modes to get juicy perks that lower-level characters don't have to eventually sell them for profits on a secondary market. This is the play-to-earn mechanic. There are three main types of activities in which users can participate in, i.e., races – compete in races through the map and try to cross the finish line before the others -, shooters – team deathmatch free to join in which players use weapons to tear down their enemies -, and vibe collectors – race against others while collecting coins named "vibes" throughout the map to refill your stamina. Maps are all created by the community.

Blankos support two different in-game currencies – i.e., MOOLA and Blanko Bucks. The latter is the game's hard currency - purchasable against fiat - that can be used to buy items, NFTs or accessories. MOOLA is instead the in-game soft currency which, unlike the main currency, can just be earned by playing and spending time in the game and used to purchase emotes, build items or other accessories.

Recently – August 2021 -, Burberry and Blankos Block Party joined a partnership to launch limited-edition NFTs (in limited quantity - 750) designed by the iconic luxury brand in the Blankos marketplace. This collaboration was one of its kind - being one of the pioneers for the fashion industry, paving the way for the future of digital ownership in gaming. The collaboration – celebrating the new TB Summer Monogram collection - reflects how Burberry seeks to connect with their gaming community, encouraging it to interact with the brand in an environment that brings this new customer experience to life and hails design, art and exploration, perfectly resembling the values that the luxury brand embodies, as the Burberry's CMO explained.

Figure XXVI - "Sharky B Blanko Burberry"

The brand house launched also its own branded accessories as part of the collection such as a jetpack, swimming shoes and armbands in the non-fungible token format so that can be worn by any avatar character players own. Sharky B – the Burberry's Blanko avatar – can be trained to learn various skills such as speed and agility to make each Blankos' traits unique. Both shark avatars and accessories are purchasable with the Blanko Bucks. Moreover, due to the capability to trace its history through the blockchain, any time the character is sold and change hands, Burberry makes money from a royalty. Currently, Blankos' marketplace is in Beta version and until then, Mythical Games will act as the custodian of players' private keys. In parallel, the publishing gaming house is working on solutions to bridge the private blockchain with the Ethereum main net allowing players to use their own wallets.

As reported by Ledger Insights (November 2021), blockchain gaming is attracting big money. Not only Blankos Block Party, for which Mythical Games raised a $ 150 million series C round – totalling the amount of $ 280 million considering also all the previous rounds, i.e., pre-seed, seed, series A and B (TechCrunch, 2021). In October, venture capital Andreessen Horowitz led a $152 million round for the Axie Infinity game. Softbank led a $93 million funding for The Sandbox game. Ubisoft financed the latest $65 million funding for Animoca – The Sandbox's founder – doubling the company's valuation to nearly $2.2 billion -, following Animoca's July extended round of $138 million, bringing the total capital raised to over $ 200 million. A16z Crypto, which has supported the likes of Opensea, NBA Top-Shot and Axie Infinity projects, has called play-to-earn the future of gaming, a multi trillion-dollar industry without question. However, all these games pose serious questions whether they are fording into security territory (TechCrunch, 2021).

BLANKOS BLOCK · PARTY

Mission:

A blockchain-based multiplayer game that ties the ownership of digital assets to the ability to have fun while earning.

Details:

Status: Operative (BETA)

Year: 2021 - in progress

Focus: Playable Asset token (NFT)

Area:

Description:

- Blankos is based on a revenue model that combines a BattlePass-style subscription with a non-crypto in-game currency that users can buy NFTs with and then sell for real cash on a secondary marketplace.
- It is working on a proprietary open-source and interoperable token standard called "dGoods" for handling the virtual representation of physical and digital items.
- As per today, the game is in "early access" (soft launch) with the opportunity to experience Blankos for free.
- Currently, NFTs are stored on a private blockchain and the bridge to the Ethereum net is expected for Q1 2022

.

Platform:

- Blankos Block Party

Protocol:

- EOSIO (private EVM-compatible sidechain)

Partners:

- Creative Mobile
- CCG Lab (Cryptozoic Entertainment franchise)
- Abstraction Games

Other partners have not been disclosed yet.

Similar projects and competitors:

- Animoca Brands (The Sandbox)
- Sky Mavis (Axie Infinity)
- The Decentraland Foundation (Decentraland)

Figure XXVII - Blankos Block Party's Descriptive Card

Tokenization in Securities Market

Figure XXVIII - The traditional Securities Market Value Chain

According to a report of World Economic Forum (WEF), the tokenization of both intangible and physical properties will propel to marginally more than $176 billion by 2025 and reach $3.1 trillion by 2030. Capital market transactions take place in two types of market, which could be reshaped by the adoption of blockchain technology.

Primary market. Market in which a company issues brand new securities in exchange for money from an investor or alternatively a buyer. Most of times, the buyer must be an accredited investor and generally known to the issuer before the transfer materializes. Besides traditional tokenized instruments, real estate is becoming one of the most popular assets to tokenize – Brazilian investment bank BTG Pactual, Japanese MUFG Trust and Mitsui Digital Asset Management represent few of the use cases. However, even if technical requirements are met, regulation does restrict access. Thanks to blockchain, corporations themselves and SMEs can now hold the issuance process, without relying upon investment banks, and the process can be managed autonomously by smart contracts, which in turn can handle the origination and distribution processes without the need of intermediaries.

Secondary market. Market traditionally handled by stock exchanges and regulated institutions such as investment firms and brokers where trade of previously issued securities to other investors occurs during specific time frames. Such investors are different from the issuing company. Some new platforms such as Securitize, Nomura and Tokeny take cares of both processes, allowing issuance and secondary trading. Without relying on traditional inefficient market infrastructure, blockchain allows to streamline the whole life-cycle process of a security – Sygnum is a permissioned platform focused on a specific asset class that manages the whole life cycle -, and benefits lie also in the post-trade. For instance, Singapore stock exchange, besides offering a 24/7 accessible market, enabled a reduction of intermediaries and settlement time (from 2 to 3 days to seconds, real time). In this way, traditional CSD involved in the clearing and settlement processes and act as a counterparty is absent, as the process is entirely handled by the technology itself. However, there's still the so called "cash-on-ledger" problem that companies like R3 Corda and Nasdaq are trying to tackle through infrastructure and delivery-versus-payment applications.

Overall, the benefit of tokenization, according to a report developed by the Blockchain and Distributed Technology Observatory, can be synthetized in the following ones.

Real-time settlement. From generally 2/3 working days to seconds.
Greater Transparency. Token owner's rights and legal responsibilities are integrated into the token itself, relying on a permanent record of ownership built on the blockchain.
Greater liquidity. Assets, once issued, can be easily traded in secondary markets and moreover, allow for fractional ownership, i.e., ownership or other actions performed on a fraction of the asset, thus lowering barriers of entry and enlarging the potential pool of users that could invest in the instrument.
Greater efficiency. Tokens are integrated with info needed to validate transactions and transfer ownership, which are recorded in real-time.
Autonomous capital management. Token's features can be set in accordance to vesting period, lock ups, time revenue share pay-outs and dividends payment, all managed and executed autonomously.
New markets. Assets that do not meet eligibility criteria to host public sales can now be traded and offered to investors.

There can be recognized 5 novel different actors, originated by the adoption of the technology, and operating across different steps of the traditional value chain, exposed in the image above:

- Asset Digitization platforms. Take care of the creation of the digital twin on-chain, attaching to them lock-in periods, voting rights, trading restrictions and conditions.
- Digital Asset Exchanges. Enable 24/7 trade of assets through stable coins, cryptocurrencies, or fiat money.
- Digital Asset Management. The platform where investors can manage their digital assets, monitor the value of assets bought and dividends received from the investments and other services like the possibility to convert such value in stable coins.

- Digital Asset Custodians. Provide storage and security services for digital assets the platform through hot and cold wallets, or a combination of both.
- Digital Asset Governance. They protect interests of investors and issuing companies, offering instruments like dispute management, users verification, purchase approval and dividends issuance.

SuMi Trust - Equity Token

With the growing increase of blockchain adoption, companies are finding useful to offer the digitized version of traditional equity shares in the form of crypto tokens that allow to manage affordably and with greater flexibility the full life cycle from creation and issuance to clearing, settlement and custodial services. Traditional methods for raising capital are fraught with hassles like maintenance of books and accounts, adherence to strict stock exchanges' rules, lack of propensity to issue credit from banks and other financial institutions and difficulties encountered by entrepreneurs to invest in their businesses (Investopedia). Conversely, issuing shares on blockchain does not need any intermediary as it enables direct participation of investors at an entry price that is completely market-driven. Equity tokens are generally represented by futures, option contracts and tokenized real estate, besides companies' share. By holding the respective token, bearers are entitled to a portion of the company's profits and usually the right to vote in the shareholders' meeting.

Still, there are some concerns regarding the viability of the business model and investors' protection, besides ambiguity in crypto regulation, hacking attempts of digital assets and hard-fork risks. These are few elements that are claimed to prevent mass adoption of this innovative offering (Investopedia).

Below, a description of a recent launch (August 2021) as part of a pilot project of tokenized equity is provided. Sumitomo Mitsui Trust is one of the largest banks in Japan that has taken part in one of the two main consortia for tokenized securities services, i.e., the JSTA, that is working with startups Securitize, Bitflyer and Tokensoft to work on a solution for the issuance and management of tokenized real estate securities.

Figure XXIX - Sumitomo Mitsui Trust Bank's Descriptive Card

BME - Funding Token

In this section, a use case of funding tokens will be analysed, i.e., financial instruments issued by companies and fueling their debt, in contrast with equity financing explored above. In debt financing, the capital is borrowed for business purposes without giving away any equity of the company. Another difference lies in the repayment schedule. In fact, the capital must be repaid at a fixed rate over a set time period. Financial review of the company, its assets and growth potential are inspected thoroughly prior to the lending. Funding token includes bonds, bank loans, credit unions, business loan providers and crowdlending. This type of financing is usually undertaken by mature corporations and SMEs needing to unlock liquidity for normal business operations.

The trade finance ecosystem has recently undergone a boost in DLT operations as small and medium companies are struggling to get by during the pandemic and can hardly remain operational. The pandemic has accelerated the shift towards trade digitalization, with the potential of DLTs to remove many inefficiencies that prevent and hassle international trade. A report from Standard Chartered, 2020, showed a global trade financing gap of nearly $ 3.4 trillion to return to the pre-pandemic levels of 2019 and meet the UN's sustainable development goals to minimalize inequalities and reduce poverty. In fact, it seemed that credit rejection tendency has been more spread out in emerging markets.

After a successful pilot back in 2020, a Spanish Stock Exchange is performing tests on a codeveloped sandbox to work on its blockchain infrastructure with the aim to raise capital for SMEs through the issuing of participatory loans and convertible notes in the form of tokens, living onto the Ethereum blockchain network. Other investments firms

are helping in the KYC/ due diligence and for marketing and management purposes. The Stock Exchange would act as an intermediary, defined itself as a "fast track to the BME Growth Market", by networking companies seeking funds with private and institutional investors and eventually converting their tokenized loans into capital or initiate the application process for the listing of the shares on BME Growth.

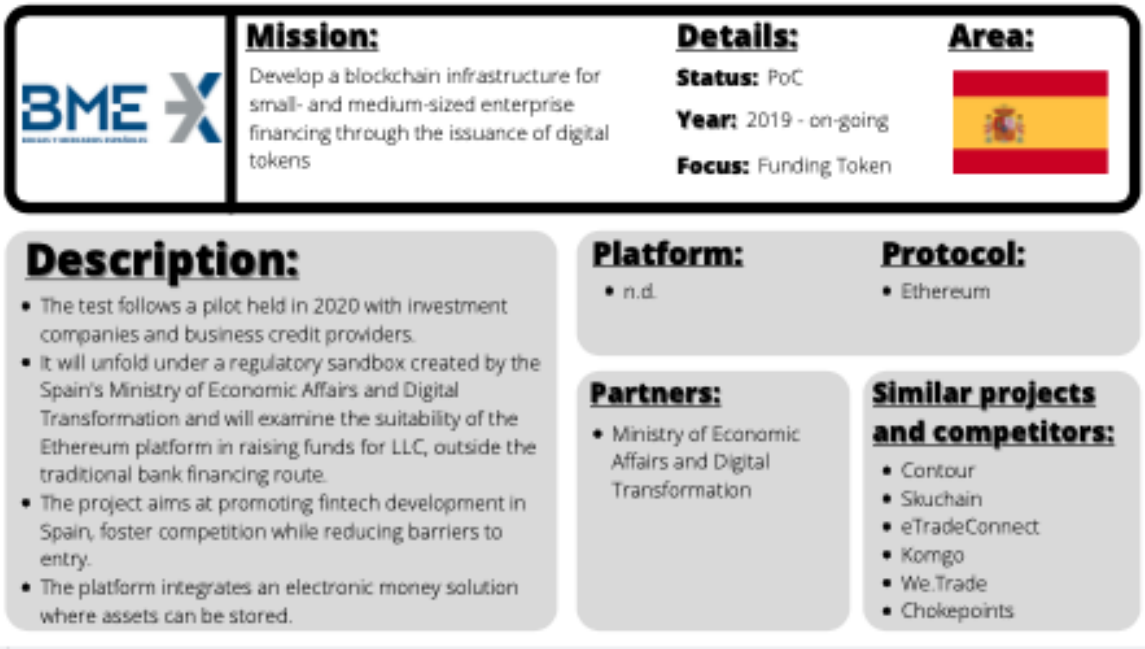

Figure XXX - Bolsas y Mercados Espanoles's Descriptive Card

Fan tokens - Membership Token

The membership-like logic has been already embedded inside previous NFTs' projects, however not tackled by the work of Olivera but heavily stressed by the data. Rather than offering a plain piece of art with no intrinsic utility beside certified ownership, projects behind Cyberpunks and Bored Ape have started to offer special and exclusive VIP-like perks unlockable only by those holding their NFTs, instilling a much-rooted purport of community.

Currently, sports teams financing come from media corporation, corporate incumbents – sponsors - and independent well-heeled financiers. When it comes to Entertainment and Sports in particular, the average fan has always been a passive content consumer as he does not dispose of any mean to influence their preferred team decisions, even if a demand for it subsists. Chiliz ecosystem aims at filling this gap by giving fans a say in the team's management, gamifying the whole fan engagement process and turning it into an entertainment proposition. That turns out to be a win-win solution as on one side these organizations gets access to a new revenue stream and on the other hand fans are afforded with some degree of decision-making authority.

Gate receipts have been a bit of a thorn in the flesh for most sports teams over the last year. A report from KPMG showed financial performance of top clubs in the ten European league divisions for the 2019/2020 season shrinking by € 1.2 billion in total operating revenue, i.e., -13% year on year. Many thought a possible way to rejuvenate their liquidity, exacerbated by the renegotiation of payment terms from commercial and media agreement, lied in the value proposition offered by Chiliz. The ecosystem opened up new ways for sport teams to monetize their growing fan base scattered all around the globe allowing them to sell fans the right to vote on specific team decisions dictated by the clubs themselves, which directly affect real-world sport events. This happens through Chiliz's voting platform Socios.com thanks to blockchain based fan tokens for reliable deployment of tokenized voting rights guaranteed by smart contracts self-execution logic on the platform.

Chiliz ecosystem contemplate 4 different tokens:

- CHZ, or Chiliz token, is the native digital currency fueling Chiliz blockchain – EVM compatible - and the Socios.com app, built using ERC-20 and BEP-20 compatible standards. It's just like ETH or any other cryptocurrency functioning as a store or value or mean of exchange. To buy fan tokens supporters need first to purchase CHZ via the marketplace on the Socios app.
- Fan Tokens. Digital fungible assets ERC and BEP compatible that act like loyalty membership pass or licenses to access a community. By holding enough of them in their wallets, fans can participate in polls, get access to merchandise discounts and access unique experiences like special grandstand access on match days or even getting their hands on a shirt signed by their sporting heroes and much more. Few games and quizzes may not require any fan token to participate in.
- SSU Loyalty Token. Each time users correctly completes team-related activities like quizzes, games and polls or even buying or transferring fan tokens, they get rewarded with XPs. These points contribute to level up a user profile so that every time a new level is achieved, SSU tokens are earned. These tokens are needed – together with a bunch of fan tokens that must be possessed - to be exchanged with the rewards or experiences fans can get access to. Of course, as the value of the reward increase, so does the amount of loyalty tokens necessary. Likewise, these tokens might be earned for free through the Token Hunt, an augmented reality game that harnesses geo-location to allow fans to go around literally "hunting" as many tokens as they can catch.
- Locker Room Tokens. This interesting mechanism that replicates staking aims at suggesting potential partnerships to work out in the future by creating virtual lockers where users can deposit CHZ – in exchange for locker room tokens - for each potential collaboration with a new club. These deposits are open just for 120 days after which a partner may decide to launch a fan token. In the case a partner opts for this decision, locker tokens will be swapped at 1:1 rate for legitimate fan tokens and get a further bonus cashback in CHZ. On the other hand, if the collaboration shipwrecks, at the end of the predefined period those tokens will be converted back into the original CHZ.

Recently, Socios teamed up with Enjin to create ERC-1155 Ethereum-based digital collectibles for partner clubs that can be minted in limited-edition to commemorate some real-world sporting achievements and granting owners prizes like exclusive VIP box stadium's access.

Fan Token holders can express just once per poll with a weight determined by the number of tokens possessed. In principle, if someone holds 5 Fan Tokens, their vote will count as 5. However, it is up to the club decide how many voting rights one supporter can have to ensure fairness. Holders can continue to bid until a token cap – decided by the club – is reached for the given poll. During the voting process, tokens are not burned, so they can be used open-endedly without restrictions. Through the app, each team partnering with Chiliz gets listed its own Fan Token and naturally they can only vote for events related to the team whose token they hold. Once onboarded, the club hosts a Fan Token Offering, like an ICO, in which a portion of a finite number of tokens are offered at a fixed price – priorly agreed upon by the club and Socios - to early public in a kind of private sale before being released officially to the public. It pertains to the team decide how many tokens – finite - to be issued based on the fan base size.

Curious is the burning algorithm adopted by Chiliz related to the tokenomics of Fan Tokens. The more the fan token holders there are and the better the team performs in terms of results or goals scored, the less the tokens in circulation there will be as the more the tokens that will be burned. However, a very small fraction of the total supply is circulating, and the rest of the tokens held by the management or team with linear vesting schedule over time, with quite of inflation.

What is huge is the possibility to replicate such model in practically any sports. As a matter of fact, Socios.com started just by listing football clubs but as observed throughout the period analyzed, in 2021 it managed to on-board clubs coming from disparate leagues like Formula 1, MMA and even e-sports, totaling over 40 partnerships as per July, 2021. Recently, Chiliz CEO announced a $ 50 million investment to expand operations across the five major US sports leagues including MLB and NFL. At the time of writing, fan tokens market cap currently stands at nearly $ 700 mln.

Payment Token

All the crypto assets whose sole purpose is a decentralized and secure payment method within a given ecosystem are embedded into the one-catch-all "payment token" definition, with further specifications of the precise type of asset used to perform the operations provided in the current paragraph.

These assets are designed to replace money and used as mean to exchange value without intermediaries: buying and selling of goods, unit of account (Conley 2017) but over time also – secondary uses - investment and storage of wealth (Wenger 2016). Amidst payment crypto assets, it is possible to distinguish the following.

1. Cryptocurrency

Bitcoin, Litecoin, Ripple, Monero are the first examples of crypto assets of "native" type as they interact with their native blockchain. They represent the first frontier of the Internet of Value and were primarily introduced to challenge the traditional pillars of the financial system: facilitate the exchange of value without going through central intermediaries. Their ambition is to become a widespread digital form of currency (Olivera et al., 2018). They do not represent any underlying asset, claim or liability, and are prone to high volatility due to their relative newness along with doubtful properties and uncertainty of future value.

Volatility pain point has made these assets more disposed to speculatory activities and called for alternative solutions that could bring these cryptographic instruments closer to the scope they were planning to fulfill in origin.

The projects studied encompassed very few cryptocurrencies, signaling how these types of tokens are out of scope by incumbents and corporations.

2. Stablecoins

Huge price fluctuations of cryptocurrencies have made it difficult for people to use them in everyday life. By tying ("pegging") their value to other physical assets, stablecoins - built upon existing blockchains as ERC-20 mostly - offer a valid alternative to currencies as their price is kept much more stable while maintaining the security and efficiency of virtual assets transactions.
According to the European Commission, the fact that the value of stablecoins is somehow pegged to reference values makes it more likely that, at some point in the future, this type of crypto assets will reach systemic reach (Il Sole 24 Ore, 2020).
Their primary role to allow mainstream payments is on its way to take off in banking sector to lower the costs of settlement and reconciliation activities. This class can be further narrowed down into 4 main typologies.

a. Fiat-backed stablecoins

Fiat money such as U.S dollar, Euro, … are used as a storage reserve on a 1:1 basis and play the role of collateral. Thus, they could in principle be redeemed by users at any time for the corresponding amount of underlying that backs them. Since is central banks' interest to maintain collateral price stable, a stablecoin is highly likely to maintain its value constant over time.

Tether – USDT – is by far the largest stablecoin in the game with a market capitalization of $ 64.6 billions. Other leading fiat-backed stable coins include Circle and Coinbase's USD Coin – backed by US Treasury Debt, market cap $ 33.7 billion - and Binance USD ($ 11.4 billion).

b. Asset-backed stable coins

As the word itself suggests, they hold a physical asset like gold or other commodities such as real estate as reserve. Since they are linked to a specific amount of the physical asset that backs them and stored in safe vaults or location, they are subject to strict audits.

Tether Gold (XAUT) and Pax Gold (PaXG) are example of gold-backed stablecoin being backed by a fine troy ounce stored in vault and redeemable for the precious metal.

c. Algorithmic stablecoins

Also referred to as "seigniorage-style" coins or non-collateralized, they combine openly auditable smart contracts and algorithms to maintain price stability by creating or destroying tokens to keep their value close to the target fiat currency it aims at tracking, thus basically relying on market forces of supply and demand. This means that if the market price of the coin falls below the value of fiat money it sticks to (e.g., usually the US dollar), the algorithms will remove tokens from circulation to increase their price and vice versa. In this way, algorithms that do this can be seen as a decentralized form of virtual central banks.

Ampleforth (AMPL) is the longest-running ERC-20 algorithmic stablecoin. With AMPL token holders own a fixed portion of the circulating supply rather than a fixed number of tokens to facilitate the "rebase", i.e., automatic supply adjustments. Terra USD (UST) is another popular algorithmic stablecoin and the biggest for market capitalization (over $ 7.4 bln).

d. Crypto backed stablecoins

These are backed by a basket of one or more cryptocurrencies to the extent that the overall underlying's value is higher than the issued coins – i.e., overcollateralization. This is somehow necessary due to the highly volatile nature of cryptocurrency market to maintain a constant peg to the target (whether fiat or cryptocurrencies) and make sure that the system can face extreme conditions (MakerDAO "black swan" in early 2020). They are similar to fiat currency except that collateralization – peg - takes place on-chain through smart contracts and technical implementation is more complex such as algorithmic ones.

Dai (DAI) is the most popular crypto backed stablecoin running on the Ethereum blockchain and managed by the Maker protocol and MakerDAO decentralized autonomous organization, according to which MKR holders can vote on issues concerning the Maker protocol (e.g., stability fees to withdraw stablecoin). It's soft-pegged to the U.S. dollar and count a market capitalization of $ 5.7 billion. Users are required to maintain a margin of at least 150% ovecollaterilazation with respect to the amount of DAI generated.

3. Central bank digital currencies

A Central Bank Digital Currency (CBDC) is a "*digital form of existing fiat money, intended as legal tender", "issued and managed by a sovereign institution as the central bank*". That is "*a central bank liability, denominated in an existing unit of account, which serves both as a medium of exchange and a store of value*" (IMF, International Monetary Fund, 2018). A CBDC is an electronic record of a country's official currency issued by a nation's central bank.

The global financial crisis has exacerbated people's lack of trust in banking system and central banks have felt under pressure to respond to the pronounced development of cryptocurrencies, a threat to the traditional roles that CBs plays in monetary policy. Reasons for their adoption lie likewise in massive efficiency gains obtained by streamlining the implementation of fiscal and monetary policy.

CBDCs come in different "flavors" according to their usage finality, amongst which it is possible to distinguish the following.

- Wholesale CBDCs

Just like Central Banks' traditional reserves, wholesale digital currencies are employed by financial institutions holding deposit at the CB for interbank settlement.

Nowadays, each bank manages a centralized ledger in which it keeps all the transactions. With the introduction of wholesale CBDC, copies of the transactions' history are stored and shared among the financial institutions but administered by the country's central bank, which in turn may decide who can have access or alter the register. Being programmable money type, conditions are set so that a transfer would not occur if they were not satisfied, thus reducing counterparty risk and making room for delivery-versus-payment in real-time gross settlement systems.

Wholesale CBDCs appear to be less disruptive – incremental innovation - and their utility would boost the global payment system by making it safer, faster and cheaper.

- Retail CBDCs

Involve the issuance of central government-backed currencies directly to the public as a digital extension to cash and banknotes.
Each central bank will issue its own digital currency used by the population and companies for ordinary payments. Consumers might not need any bank account to access their funds. This is one of the reasons urging emerging economies' governments to promote financial inclusions and target the unbanked.

Retail CBDCs eradicate the risk of commercial banking institutions becoming illiquid and sinking depositors' funds. At the same time, they pose a threat to commercial banks, whose clients, in periods hit by financial crisis, could withdraw their deposits to convert them in CBDCs, thus creating a financing problem for the whole economy.

Cross-border payments represent other suitable area for wholesale and retail CBDCs applications enabling transfer automation and shrinking the number of intermediaries (i.e., wholesale connections won't be needing anymore to rely on correspondent banking). However, these linkages are particularly affected by the typology of configuration used, discussed below.

As just anticipated, another classification pertains to the central bank currencies configuration whereby it is possible to classify the followings.

- Account-based.

Similar to deposit or bank accounts which institutions or users set up to carry out transactions, as the name suggests, account kept at central bank is used to store currencies. It requires verification of the identity of both sender and recipient by an intermediary, resembling the system used today for managing digital payments. After transactions occur, the central bank will adjust accounts' balance.

- Token-based.

In this case, currencies are moved across pseudonymous digital wallets, most likely publicly identified on a public blockchain, with the use of public-private key pairs and digital signature. It requires verification of the validity of the "object" used to pay. Higher degree of users' privacy and accessibility is ensured at the expenses of funds recovery in case of lost keys.

Design Architecture of Retail CBDCs

According to claim structure, responsibilities of the players involved, and records, three main forms of architecture can be derived, each of which might be realized using either a token or account-based approach with no restrictions. Keep in mind that, whatever design, CB is the only party issuing and redeeming CBDCs.

I. Direct Issuance.

CB issues currency directly to end users and manage a centralized ledger where it keeps track of the transactions. Just as banknotes' function before Breton Woods, individuals have a claim (IOU) against the central bank. Despite the simplest model to implement at first sight, it is full of hurdles as private sector is completely cut out from payment

services and CB must handle all the technical-related aspects (on board KYC/AML included).

Figure XXXI - Direct Issuance of CBDCs

II. Two-tiered Issuance (Indirect).

CB issues CBDC to commercial banks, which in turns have the duty to on board consumers and handle payments with the public (households and merchants). This is the closest structure to the current financial system – that is why the name "two-tier" - whereby central bank manages only wholesale accounts and reconciliation. If on the one hand CB is free from the burden of setting up a proprietary network, on the other hand users' claims are exerted against and kept track by intermediaries, thus not solving the current trust issues towards private institutions in periods of stress. CBDC is accessible only to banks while an ICBDC is handed over to consumers. Such ICBDC must be fully backed by deposits at CB.

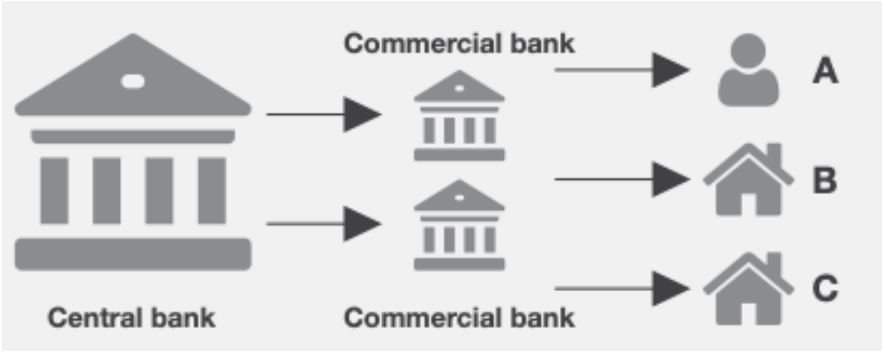

Figure XXXII - Indirect CBDCs' Issuance

III. Hybrid CBDC

It combines the benefits of the previous configurations, i.e., preserving users' claims against CB while letting private institutions enter the system and manage the "complex" stuff related to operations and payments processing, taking advantage of already

consolidated networks and scale economies. CB will keep track of transactions by periodically retaining a copy of the ledger and detach claims from the register used by retail payment providers. This way CB can focus on core processes such as monetary policy, intervening only whenever a provider fails to meet its obligation, guarantying smoother migration towards other processors thanks to claims' portability which enables balances' restoring.

Figure XXXIII - Hybrid architecture of CBDCs

The Smart Money project – Retail CBDC

A 2020 report on digital euro published by the European Central Bank claimed how the Eurozone would have decided whether to pursue any formal retail CBDC project and stating that a go-ahead to start working on a formal project would not necessarily follow up with any commitment to issue one. The main drivers are related to greater financial inclusion and to support digitalization within EU. Recently, Iberpay, the main payments infrastructure provider in Spain, and Bank of Spain have been on the move should the central bank's decision become reality, so that a feasibility study would have already been carried out prior to the potential release of a digital euro on the market. The study successfully conducted tested many different features. A Working Group composed of the main top-level experts to discuss legal, innovation, technical and policy implications was set up to provide a multidisciplinary approach to the initiative. The following conclusions were drafted.

- Preference for a two-tier infrastructure model, in which the ECB will maintain liability but with the aid of financial sector to distribute such euros to end users, in line to the ECB's statements and the inability for the Central Bank to manage all the process alone. In this way, current distribution channels would be maintained without the need of further investments.
- Coexistence of an account-based and token-based model within the same infrastructure, with annexed risks.
- Viability of offline payments should continue to be explored to manage all the possible constraints (QR codes standardization, NFC's usage restrictions, …).
- Possibility to apply maximum holding threshold and in digital euros usage, both in online and offline payments, thanks to the ability to incorporate programmability solutions.

- It is considered necessary to implement digital identity into end-users' wallets.

As it handles the entire Spanish payment system, holding 98% of the Spanish market share across 17 banks and plays a key role in the distribution of physical cash to financial entities in Spain, Iberpay could represent the gateway for a wholesale distribution of an eventual digital euro, benefiting from regulatory supervision in the management of the Spanish Payment System and taking advantage of its payment connections with the European Central Bank.

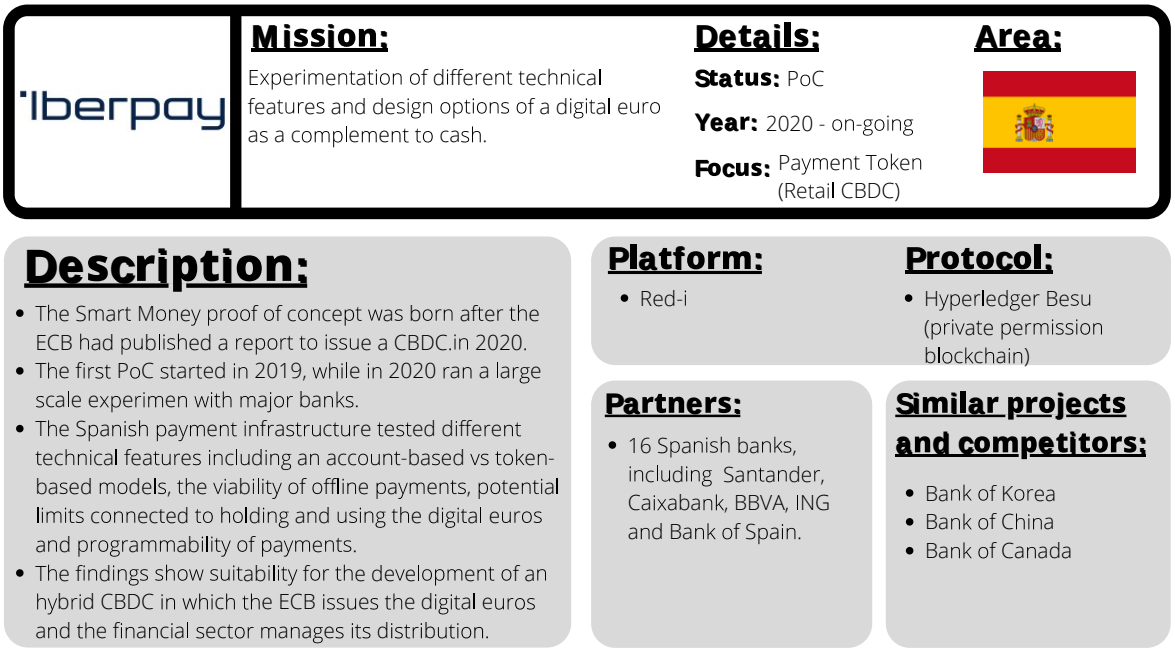

Figure XXXIV - Iberpay's Descriptive Card

This represents one example of how research on central bank digital currencies (CBDCs) has increased around the world. Several countries, including Canada and China, are conducting pilot programs, while Nigeria launched a CBDC in October 2021. The United States and Europe, however, have moved at a relatively slow pace.

6 Findings & Conclusion

The objective of this thesis was to try to fill the gap with the current knowledge in literature, delivering insights from a tangible analysis of projects and use cases that harness distributed ledgers technologies for the implementation of digital assets, i.e., tokens. Particularly, the work aimed at investigating opportunities offered by digital assets within ordinary companies' business models and eventually, the benefits they can provide.

Present Industry Overview

This section aims at providing a clear cut of which industries are currently most impacted by the tokenization process, along with their correspondent state of progress, to address the RQ1. Finance (26%), Art & Entertainment (37%) and Government (14%) are the major domains of investigation in 2021 and, except for the latter, they count the highest number of "live" projects (28% and nearly 50% respectively in the current year), amongst the overall operative ones. Art & Entertainment was the only sector to experience a massive upsurge only since the previous year (from 1 to 30, +2900%). This is supported also by the fact that many projects in such areas have been just recently announced. Such figures are partly driven by the boom in gaming applications and collectibles NFTs, among the 2021 main trends. However, considering the entire time horizon 2017 - present, not reported in the picture, Government sector is still one of the most dynamic after Finance despite many of the projects are explorative in nature and research still on-going. In fact, as the chart suggests, no one of the governmental projects analyzed haven't seen the light yet. Another industry to highlight in terms of recent growth and counting most "operative" projects as per today are Fashion & Luxury, partly correlated to the world of Art & Entertainment, and Media & Telecommunication but still accounting for the 9% of the total projects in 2021.

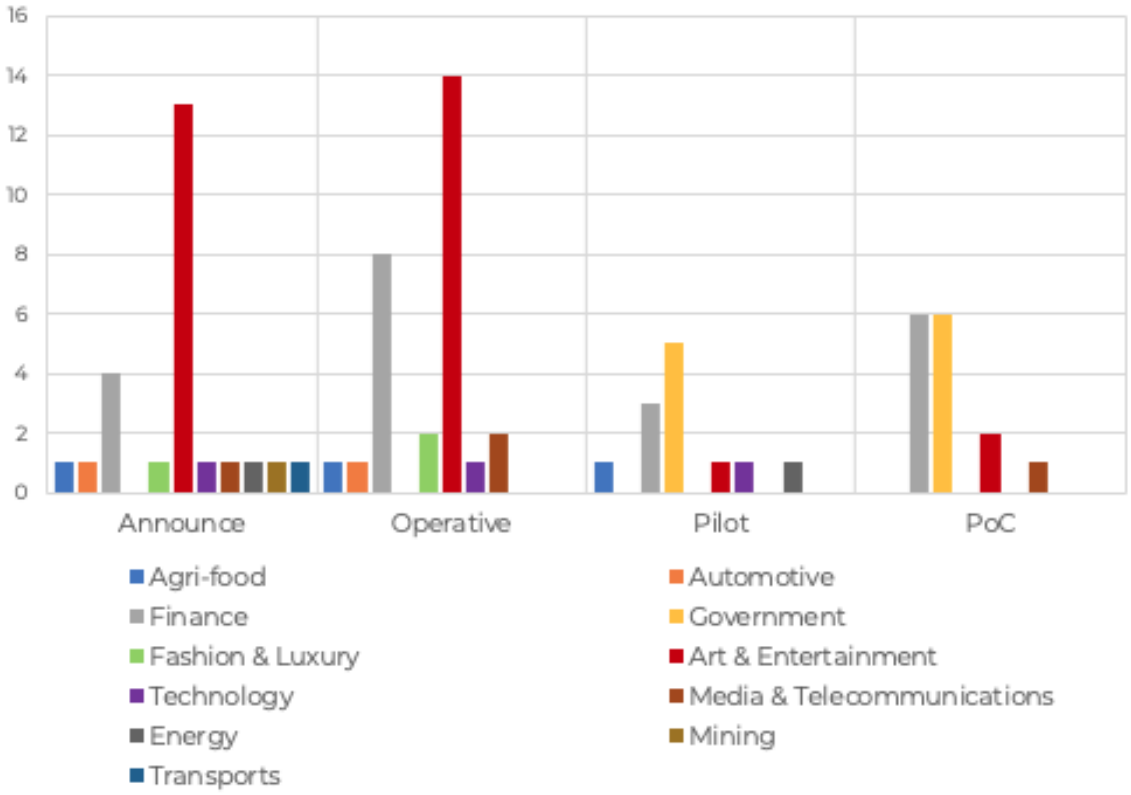

Chart 14 - Number of projects split per Industry in 2021 (cases n. 81)

Process Impacted

Each project has been examined, as long as the information was accessible, to investigate the way private companies and public administration are employing business tokens and what are the main processes impacted (RQ2). The chart below resumes which are the main ones touched upon by the censed projects. Note that the usage of cryptographic assets inside a business environment is not so widespread and deserves a deep study of a company's business model as underlined later, yet, as per the cases observed, it encompasses applications bounded to somehow disparate but standardized use cases. Usage features will follow through in the next chapter.

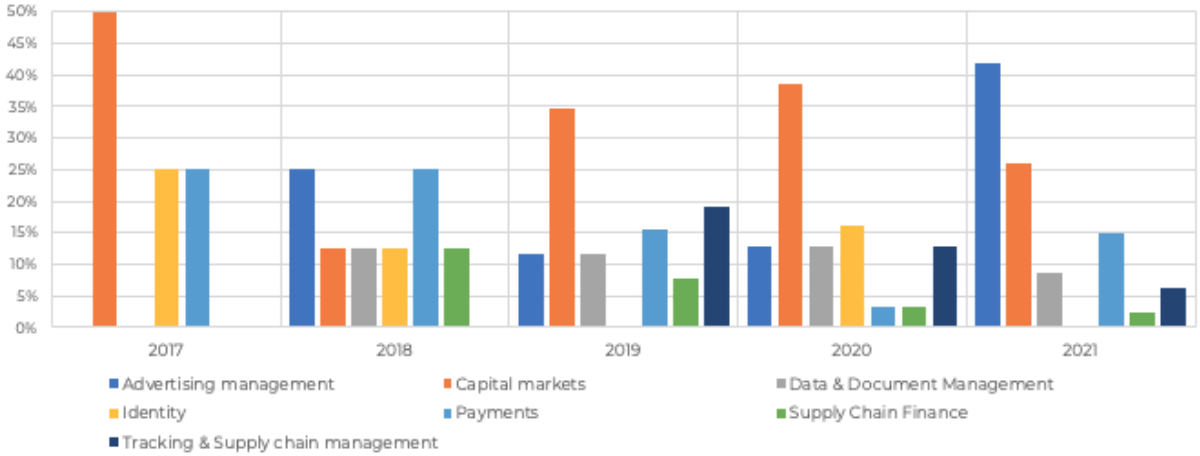

Chart 15 - Impacted Processes (cases n. 150)

At a first glance, it appears evident the predominance of Advertising Management (29%), Capital Markets (30%) and Payments (14%) over the whole investigated time horizon and reflected by their more consistent growth in terms of absolute values; Data & Document Management projects are gradually increasing year-to-year and currently, placed a bit behind, accounting for almost the 10%. Payment underwent a decrease during 2020, overcome, among the others, by Identity (16%), Data and Document Management (13%) and Tracking and Supply Chain Management (13%) domain related activities of overall 2020 projects (32), to eventually soar again during this year. By looking at the growth rate since the spread of the pandemic, what is blinding is the steep upsurge in Advertising Management-related activities, which can be explained by the mainstream explosion Web 3.0 applications attracting customers in fun and exciting initiatives. During Covid-19, forced to stay at home, it was almost inevitable for most of the people, especially the younger, to find enjoyable activities that would keep them busy. The same reasoning cannot be made for Tracking & Supply Chain Management, however after 2019, no or limited growth could be witnessed, and it is currently standing at around 6%.

By crossing the results obtained from the two previous analyses, it is noteworthy to underline how Payments, which was basically the main field for blockchain technology tokens' applications since its introduction, account for less than a half of the use cases in the Finance industry, where instead most of projects are related to Capital Markets – i.e., tokenized securities launched in primary or traded on secondary markets.
Moreover, Advertising management-related applications are becoming ones of the most dynamic and cross-cutting areas of domain, from just two different sectors in 2018 to 9 different sectors in 2021, + 350%. As the pandemic hit profoundly companies' balance sheets, many were the cases of firms exploiting their dominant position or yet affirmed network in their respective sectors to launch fan engagement and loyalty initiatives targeted to their solid customer base, following a quite standardized approach. For instance, in the Football industry the UEFA calculated a loss of over € 8 billion, making almost necessary to reinvent themselves (CalcioeFinanza, 2021). A similar reasoning can be made for Capital Markets, more reasonable as more companies are tapping into investors' pockets to request funding or making their assets more liquid – from 2 in 2017 to 6 sectors in 2021 (+ 200%) - and Data and Document Management-related applications – from 2 to 5, +150%, in the same time horizon – but still in a less pronounced way than

Advertising management. In the case of Data and Document Management, companies belonging to the same industry felt the need of a shared space where valuable information could be safely kept and managed, guaranteeing more transparency and increased efficiency.

To recap, the most impacted processes from a token adoption perspective:

- Advertising Management
- Capital Markets
- Payments

The above considerations can find an explanation by the following analysis which compares Sector and Process Impacted. As we can appreciate from the chart below, token applications but Advertising management are more routed towards precise sectors - let's think of Tracking and Supply Chain Management, Payments, Supply Chain Finance and even Data and Document Management until few years ago. This might be due to the fact finding the best suited token-centric business model in contexts like Tracking and Supply Chain Management or Supply Chain Finance is more arduous, challenging and requires more actors involved. Despite it, by merging the data from Chart 2 and 3, it is possible to witness how this tendency is likely to disappear. For instance, zooming in to Tracking and Supply Chain Management, it is observable how in the current year, despite the overall projects being the same as in 2019, they are more diversified with respect to past use cases. This is explained due to a growing number of companies running in different industries that are finding a shared ledger regulated by a utility token a very appealing alternative.

Sector per Impacted process	Advertising management	Capital markets	Data & Document Management	Identity	Payments	Supply Chain Finance	Tracking & Supply chain management	Total
Agri-food	1	1					1	3
Automotive	3	1	2					6
Fashion & Luxury	1	1	3					5
Finance	2	36	2		7	2		49
Government	2	2	1	7	10		1	23
Art & Entertainment	27	1	3		1			32
Technology			1		1	1	1	4
Media & Telecommunication	3	1	2		1		5	12
Energy	1						5	6
Mining		2				1		3
Transports	3		1		1	2	1	8
Total	43	45	15	7	21	6	14	151

Chart 16 - Analysis of the occurrences given Sector and Impacted Processes (cases n.151)

Functionalities

This section explores which are the most common functions exhibited by tokens in the most frequent processes in which they are employed and the tasks that users are allowed to perform with them (RQ2). The results presented are referred just to the most impacted ones and a more general overview of the remaining hereafter not discussed is reported in the following chapters.

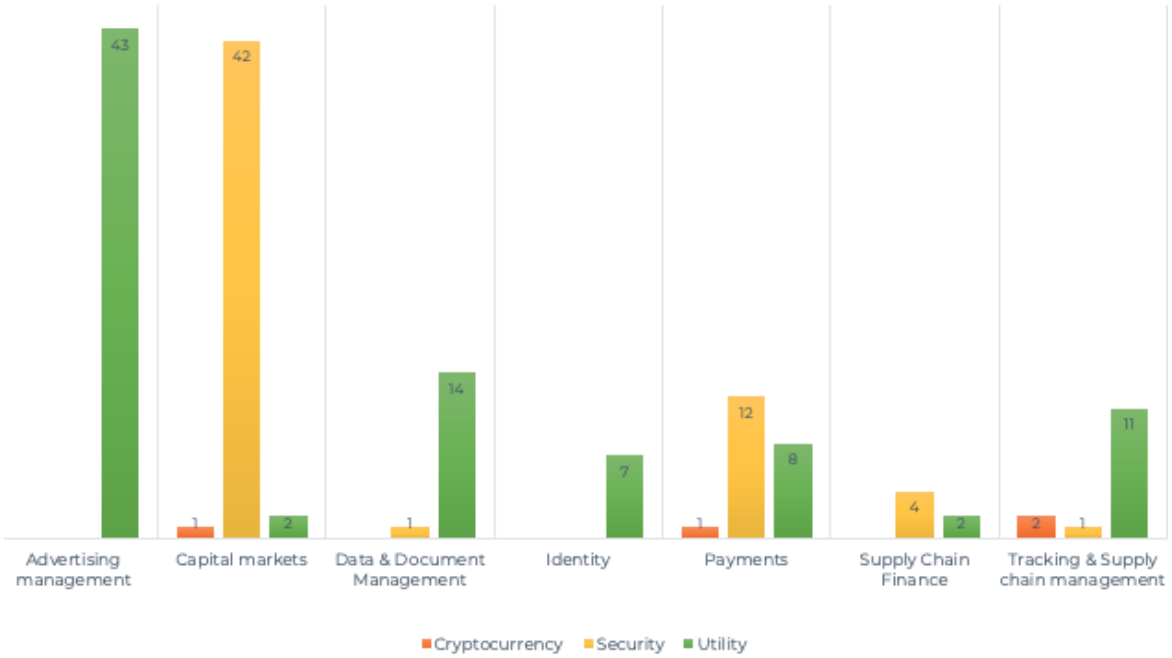

Chart 17 - Summary by Class and Impacted process (cases n.151)

a. Advertising management

Utility tokens, used both as an access pass and a reward within an ecosystem, are the most recurrent in Advertising Management.
Bear in mind that a discreet portion of projects deal with asset-based tokens, even if classified as utilities. These in fact are related to digital non-fungible collectibles or artworks as underlying. Lately, much of the debate going on in the crypto sphere pertains to whether such tokens shouldn't be categorized as securities but for now, keep the disclaimer as it is and reasoning behind will be outlined in the research framework.
Utility tokens analyzed allow the bearer to perform multiple tasks: either as an access-right to vote on daily ordinary issues and participate to challenges proposed by the platform and be eligible for recompensations (30% of total, 13/43), have an ownership claim over an underlying (37%, 16/43) or as an incentive or right to take part in the ecosystem to access a service and contemporarily be used as a value exchange mean inside the platform (33%, 14/43). While the first typologies of tokens function as an access pass to participate in a set of activities set by the issuer such polls' voting, quizzes, as well as other kinds of fun challenges, tokens pertaining to the latter category are used as a reward to actions performed by the users when interacting with the platform, helping the network to grow and enhance user experience. Such rewards might be obtained for having purchased a service or having signed-up to a given platform to perform transactions, i.e., loyalty programs – participants are simply "users" of the service - 36%, 5/14 –, governance tokens – allow the bearer to become the curator of a certain aspects of a platform and might convey the right to cash flows which come from transaction fees that are poured into a treasury fund ad-hoc dedicated – 3/14, 21% -, or simply to empower users to connect with each other and actively contribute to the platform growth – 6/14, 43%. Nevertheless, unlike loyalty points as we are used to, some loyalty programs on blockchain are backed by tokens which can be eventually cashed out for fiat and bring

real value not only to clients – access discounts and merchandising - but also to merchants that can reduce their liability. Thus, a distinction has to be made between classic loyalty points and cashable tokens. This means that "old" versions of loyalty tokens cannot be traded and follow a linear lifecycle, i.e., one-off usage for redemption - whilst instead nearly all the others (38/43, 88%) could be exchanged amongst peers and platform participants on the different sides of the platform, thus powering a circular economy.

Amongst tokens whose bearers can claim ownership over an underlying virtual asset - being it a piece of art or a collectible that can be traded on secondary marketplaces, 16/43, 37%, -, 44% of them are related to in-game digital ownership – generally of a fictitious character with animalistic features which players might feed and nurture, make it couple with its similar and eventually trade inside the in-game platform. One token allows the bearer to receive discounts or access to restricted content just by the simple act of holding it in their wallet, similar to a membership pass.

Please note that governance tokens are stuck amid security and utility tokens limbo. In fact, they resemble the characteristics of equity stocks – by giving right to a part of the cash flow of the platform – and might fall into the Equity Tokens archetype (see below, RQ3), according to the definition that Olivera et al. provide.

b. Capital market

Asset-based security tokens are the most spread in CMs - with the underlying being a digital representation of a legal contract agreed by parties (43%, 18 cases out of 42) or a share in a company (36%, 15 cases), entitling the holders to earnings rights, being them in the form of interests – fixed-price coupons with the redemption of principal at maturity – and dividends, respectively. Please note that even if a token entitles a right or claim in receiving earnings from holding the tokenized financial instrument – token -, these are not compulsory paid with the same exact token, but in some cases, they might be remunerated either with stable coins or plain fiat money. Moreover, none of the information sources mentioned the presence of rights linked to participation in boards - ordinary shares - indeed, there have been cases, 2/42, 5%, in which the opposite has been clearly stated, that is, that the token representing a share in a company does not incorporate any voting rights. It might be therefore assumed that, if a voting right is attached to the instrument, this would be made explicit through the issuance of a specific token.

Other recurrent solutions – accounting for the 12% of the total - are focusing on tokens representing a direct ownership over physical commodities (real estate, wheat, sugar, gold, luxury items, … - in case of commodities kept in a central vault handled by the platform) while the remaining stand for tokenized fiat used for securities settlement, 4/42, 10%.

Overall, asset tokenization and subsequent distribution and exchange occurs in 96% (43/45) of the cases analyzed, of which the 65% entail either asset backed-securities - "digital twin" in which the token is an ownership certificate synchronized with the

underlying security already registered on a Central Security Depository while the remaining 35% focuses on native assets registered and existing on blockchain only.

Such use cases might cover different steps along the security market value chain, whether being origination and distribution, trading and settlement or other additional services – custodial, … -, however, not touched upon in a linear way as it might happen that some of them overlap and encompass more than a single layer – cases of vertical integration issuance platforms. An example is given by those which might handle both the primary issuance and trading activities – i.e., primary and secondary market. Other stand-alone solutions addressing just a specific issue are represented by custodial and additional services – accounting for 2/45 – 4% of the projects.

It can be observed that not all the projects overviewed are completely mitigating the complexities linked to settlement. Rather, only partially. In fact, cash on ledger represents still a problem that needs to be addressed if wanting to extract the maximum value out of blockchain technology. And just nearly the 13% (6/45) of all the CMs-related projects focuses solely and exclusively on post trade activities - settlement/delivery-versus-payment automated execution, i.e., asset tokenized on-purpose to be exchanged against tokenized cash. These projects involve mainly big players and incumbents like banks or other institutional actors.

The main benefits brought by tokenization lie in efficiency gains amongst which lower costs, shorter processing times but also improved traceability along the value chain, enhanced security and lower information asymmetry.

c. Payments

Finally, as to Payments, a more balanced scenario between security tokens and utility tokens occurs. Security tokens issued by public administrations and backed by fiat money account for the 57% (12/21) of the solutions, of which 77% (10/13) in the form of CBDCs - either wholesale, 40% (4/10) of the cases, or retail, 60% (6/10) of the cases.

9/21, 43% of the projects concern utility tokens - that might reasonably fall into e-money regulation - and just one case for cryptocurrency "tokens", so split. The 22% (2/9) encompass privately issued stablecoins for interbank usage in cross border to replace SWIFT and national transfers. However, there was one use case – Eurozone - in which blockchain is used in conjunction with SEPA current transfer payment medium. Traditional cross-border payment has always been a slow process fraught of hurdles and transferring money from one country to another might involve numerous banks with delay and massive transaction costs exceeding up to the 10% of overall value. By removing middlemen and expensive reconciliation processes – respondent, correspondent banks, nostro, vostro accounts -, blockchain technology manages to speed up and simplify this process while decreasing costs along the value chain. Remaining 78% (7/9) of the cases refer to generic currencies spendable in dedicated shops or accepted by service providers. These are introduced for targeting both e-

commerce merchants and third-party developers who want to build or connect with an existing blockchain to be used to offer their products to and at the same time receive a stable - and of course, legally available - mean of payment. Such tokens allow retail cash-free purchases and are employed to buy goods, consume meals at restaurants or even send them to other network participants through easy-to-use UX mobile interfaces.

Behind the adoption of digital coins, and besides a transparent and single shared source of truth, the main beliefs are envisaged in greater operational efficiency like a reduction of settlement time, back-end processes streamline (cut administrative costs, simplify budgeting management, …), but also compelled by the accomplishment of more "social inclusive" financial goals (reach the unbanked, facilitate remittances, …) – especially in retail CBDCs applications.

Archetypes of belonging

To answer RQ3, a wrap up of the different archetypes is shown herein to assess the distribution and prevalence of the different tokens' typologies examined, highlighting the coexistence with more than one archetype at the same time. In fact, these results suggest how the categories presented by Olivera are exhaustive, but somehow, intertwined with one another, underscoring the impossibility to categorize each digital asset within a single scheme or reference model. The outcome also displays the presence of potential "sub-archetypes", merged within the corresponding primary standard of belonging. Sub archetypes are indicated to the right of each frequency and account for approximately the percentage of the corresponding line. For instance, from the left, starting from the top, asset membership tokens accounts for little less than 1%, etc.…

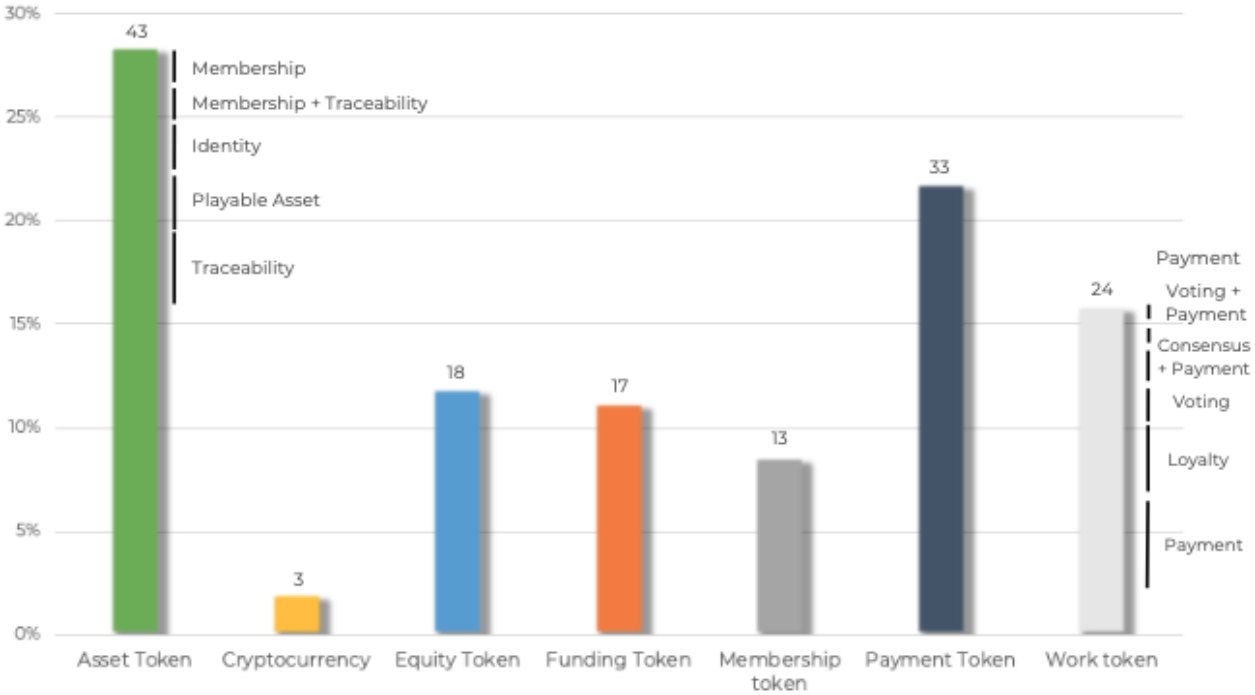

Chart 18 - Tokens' archetypes distribution. Sub archetypes are indicated to the right of each frequency and account for approximately the percentage of the corresponding line

The outcome of the research seems to substantiate the gradual pervasiveness in tokens' usage as a core element that triggers digital transformation process and foster innovation, shedding a light over disparate practical applications and how they help to make a business thrive. Whereas initiatives in such way seem to come mainly from private players, other actors like central banks and governments are a bit hesitant and seem to play for time as for how the whole technology adoption process will unfold. Public administration and local authorities are mainly using it for electronic voting, personal identity security and regulatory filings such as mortgage deeds and financial records.

Since 2019 big brands like Bumble Bee Foods, Walmart and Visa have propagandized successful blockchain deployments and blockchain is getting more and more prominence in the enterprise world, backed by huge IT players such as Oracle, SAP, IBM and Amazon Web Services, signaling how it can save up costs, help businesses expand B2B and B2C networks and at the same time create new lines of business.

Overall, the most impacted business process by the adoption of tokens, in principle related to the Payment sphere and to introduce an alternative, reliable mean of exchange, is being supplanted by other application domains, mainly related to Advertising management, covering incentive economies and fan engagement solutions mainly within the Art and Entertainment industry (examples of practical use cases are given by royalties tracking, advertising insights and original content creation) , and Capital markets, which exploit tokenization advantages to exchange financial digital securities, i.e, centralized and decentralized finance realm such as real-estate processing and cryptocurrency or other financial instruments exchanges for a minor part.

By analyzing all the possible applications in business realm, the thesis has eventually deepened the results of previous literature as a new token archetype strongly stressed by the data that was not present in previous works emerged, that is the "Membership Token", a token that awards the holder with different incentives just by the simple fact of holding it. Not only in day-to-day applications, but such token configuration has also been meaningful in the DeFi and NFT wave that has begun to permeate from 2021 onward.

Still, the potential has not yet been uncovered and reasons lie behind a lacking awareness over the concrete and practical benefits both in terms of efficiency and effectiveness that tokenization might bring, calling for it in future works. Use cases tend yet to cluster around high tech-savvy flourishing market players requiring huge coordination, in some cases amongst competitors, which is not always easy-going.

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