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# Blockchain in Trade Facilitation: Sectoral challenges and examples

*Summary*

Blockchain-based technology can have a number of usages; but these may vary depending on the sector of activity. This document goes through various sectors which identified blockchain as potentially beneficial and goes through the advantages and challenges of its use and provides detailed information about how this technology applies to each sector. When possible, used cases have been provided. As it is split into sectoral sections, the reader can consult just the sectoral points of view that are of interest to them.

This document is a work in progress. It is presented to the Plenary in order to share the state of advancement of this work. It does not constitute a position of any kind of UN/CEFACT or the UNECE Secretariat.

Document ECE/TRADE/C/CEFACT/2019/INF.3 is submitted by the Bureau to the twenty-fifth session of the Plenary for information.

1. Blockchain can have many applications, however the implementation within each sector of the supply chain may imply a slightly different approach. During the blockchain project, the project team identified a number of potential uses of blockchain in different sectors; these were divided into the sections which constitute this document. Each section was authored by a different team.

2. Each of the sections provided in this document look at the base aspects of blockchain and how it can potentially apply to their specific sector of the supply chain. When data was available, use cases were gathered using the below template in Figure 1. These use cases are presented as they were submitted; only grammar and spelling were checked. They in no way constitute an endorsement of any kind by UN/CEFACT or the UNECE secretariat.

3. This paper for information is a work-in-progress and is not yet complete. It is presented to the Plenary for information so that Member states can see the progress of this team and potential challenges and advantages of this technologies in different sectors of the supply chain. It has been prepared under the leadership of Virginia Cram Martos, under the guidance of Vice Chair Tahseen Khan. Lance Thompson, Tomas Malik and Helen Ross of the UNECE secretariat supported this work. The following experts contributed to parts of this work: Ahmed Abdulla, Jorge Alvarado, F. Ametrano, Anurag Bana, Gadi Benmoshe, Jérôme Besancenot, Mary Kay Blantz, Aleksei Bondarenko, Somine Bonetti, Alex Cahana, Gianguglielmo Calvi, Enrico Camerinelli, Steve Capell, Concettina Cassa, Jasmine Jaegyong Chang, Eric Cohen, Alan Cohn, Jesse Chenard, Sandra Corcuera Santamaria, Savino Damico, Dario Delle Noci, Nena Dokuzov, Raffaele Fantetti, Tom Fong, Ori Freiman, Jostein Fromyr, Erwan Gambert, Chris Gough, Anders Grangard, Edmund Gray, Luca Grisot, Thierry Grumiaux, Felix Guimard, Rudy Hemeleers, G. Ken Holman, Kazuo Hotta, David Huysman, Estelle Igwe, Ravi Jagannathan, Erik Jonker, Christophe Joubert, Herny Kim, Ad Kroft, Vijay Kumar M, Marek Laskowski, Colin Laughlin, Jaime Luezas Alvarado, Wassilios Lytras, Leonardo Macedo, William E. McCarthy, Pietro Marchionni, Gianluca Marcolongo, Yolanda Martinez Mancilla, Richard Morton, Harry Moyer, Jacob Ninan, Anushka Patchava, Anita Patel, Johan Ponten, Ladan Pooyan-Weihs, Peter Potgieser, David Roff, Hans Rook, Mualem Ronen, Carlo Salomone, Daniel Sarr, Aleksandr Sazonov, Michael Schroeder, Inon Schenker, L. Simpson, Fabio Sorrentino, Kaushik Srinivasan, Akio Suzuki, Tunghua Tai, Mikio Tanaka, Max Tay, Frans Tjallingii, Daniele Tumietto, Frans van Diepen, Ian Watt, Rupert Whiting and Burak Yetiskin.

| | |
|---|---|
| Section / Sector | |
| Short description | |
| Proposing / Implementing / Testing Organization | |
| Contact for further information | |
| Long description | |
| Description of potential business benefits from blockchain use | |
| Special concerns (legal, technical, etc.) | |
| Blockchain being used / proposed | |
| Type of consensus algorithm used (if the blockchain is private or permissioned / consortium-based) | |

| | |
|---|---|
| Rationale and trade offs considered when selecting a blockchain | |
| Any special hardware or other used (IoT, QR codes, etc.) | |
| Any open-source software being used / proposed | |
| Links to related information including technical white papers | |
| Other | |

*Figure 1. Standard template for blockchain use cases / case studies*

# Section I: Data security and regulatory issues on blockchain based distributed ledgers

## A. Introduction

1. Electronic commerce often involves transactions between parties where there is a need to establish reliability in the exchange and transparency. Blockchain, a type of distributed ledger, ensures tamper-proof digital transactions through the use of cryptographic technology and automated consensus.

2. While Blockchain is designed to be trustless, the need for establishing that participants are who they claim they are is important to ensure the identity of participants and, where required, the legality of such transactions. This is particularly true of cross-border trade where identity and identification mechanisms may be different, and a common framework related to Blockchain must be defined and adopted if the resulting records are to be legally accepted on both sides of the border in question.

3. Laws and regulations and/or the parties using blockchain data for authentication, often define the level of risk assurance, accuracy, integrity and privacy required for data stored on a blockchain to be accepted. This drives considerations for data design and mechanisms for authentication, authorization or consent that need to be put in place for the legal recognition of transactions on a Blockchain system.

4. Like other systems, to ensure security within a Blockchain, user roles and access rights must be specified in detail during the system design stage as it may be difficult to change access rights later. Some examples include restricting access so that some users can only: write to the blockchain under specific, defined instances; perform certain queries; and/or interrogate a limited set of data. Various roles that could be specified include users (of different types), miner, validator, administrator and auditor.

5. Distributed systems, with many users, are difficult to manage and maintain. When distributed systems are governed by a majority consensus of users, this can present additional security challenges. Within Blockchains, changes are implemented through forks, of which there are two types:

- Soft forks - These represent software changes that do not prevent users from using the changed Blockchain system.
- Hard forks - These are software changes that prevent users who have not adopted the change from using the changed Blockchain system. This requires a decision from users to either upgrade and stay with the main fork or continue without the upgrades and stay on the original path. Users on different hard forks are prevented from interacting with each other, which helps to avoid conflicts between ledgers.

6. As with all information technology systems, developers are responsible for changes to the underlying software. These developers maintain some level of control over the direction of the blockchain on which they are working, primarily the power of proposal. For example, a group of developers may recommend a change in the hashing algorithm changes or changes to the block structure. These proposed changes will then require a majority of the nodes (validators) on the network to agree and require a hard fork. It is very difficult to obtain the permission of a majority of nodes for a hard fork, thus the underlying difficulty in maintaining and updating blockchains. As a result, it is important to look at the governance mechanisms in place when selecting a blockchain and at the trade-offs involved between stability and the ability to evolve over time. Forking also has a role in identifying data errors and fraudulent transactions, as discussed below.

7. Another key aspect that must be kept in mind when using Blockchain is the security of users' private keys. Users' private keys must be managed and kept secure since there is no centralized management system. If a user loses their private key, all assets related to that key are lost as well, unless a way to recover that key has been put in place. On the other hand, the classic solution to this problem, the creation of a centralized key management system, would most likely create a single point of failure, and such a system would no longer meet the basic principles that a distributed, decentralized model of trust is based upon. As a result, creative solutions are needed.

8. While some of the key information security, legal and governance aspects of Blockchain ecosystems are described in this chapter, there are many more such as standards, transaction rules, technology assurance and audit trails which may be critical to the cross-border acceptance of trade documents. This may require definition of a common framework based on which records in a blockchain system can be accepted across multiple jurisdictions. Where different blockchains are used there is also a need for both a common technical framework and a common governance/design framework that will allow the exchange of legally accepted records.

9. Since blockchains rely extensively on cryptographic techniques, the development of quantum computers[1] will require changes to the cryptographic technologies used in blockchain systems. It is widely known that quantum computing will render many existing and often used cryptographic algorithms useless. For example, the United States' National Institute of Standards and Technology produced a report on post-quantum cryptography, which showed that three well-known encryption technologies (Rivest, Shamir and Adelman algorithm [RSA], Digital Signature Algorithm [DSA] and Diffie-Helman) will no longer be secure and the Advanced Encryption Standard (AES) and Secure Hash Algorithm-2 (SHA-2) and SHA-3 standards will require larger key sizes and output to be effective.

10. This section focuses on various security aspects related to Blockchain that should be kept in mind when designing an application using a blockchain-based distributed ledger. These include -

- Identity and Identification
- Authentication and Authorization
- Data Accuracy, Integrity and Time Stamping
- Privacy, Confidentiality, Accessing and Sharing Information
- Legal aspects relating to use of Blockchain

## B. Identities and identification

11. We increasingly need to prove our identity to third parties, each with different authentication assurance requirements. Despite the move towards digital transactions in both the private and public sectors, we continue to rely on physical identity documents (which can be counterfeited with increasing ease) and username-password authentication processes (susceptible to breach given their centralized nature). Consequently, the need for reliable digital identity solutions is increasingly pressing and is critical to enabling digital transformation and inclusion of society as a whole.

[1] Foreseen to be available within the next decade, see https://www.scientificamerican.com/article/how-close-are-we-really-to-building-a-quantum-computer/ (as of January 2019)

12. It is estimated that 1.1 billion people live without an officially recognized identity.[2] This results in their inability to participate in commerce, financial markets and get access to services such as healthcare. An accurate and accessible identity system allows for inclusion and participation in global trade.

13. Blockchain holds promise in this regard and could be used to create and verify digital identities, for individuals and organizations. These identities could be based on one or more indicators, which might include, for example, community endorsements, past transaction histories, and/or biometric data.

14. There are multiple types of identities that we use today in online and offline transactions. These identities range from

- Social ID's (social media) – No Proof of Identity Guidelines and completely digital
- Private ID's (e.g. employee ID) –Proof of Identity Guidelines are defined by the issuing party (e.g. employer) and are mostly physical
- IDs issued by Government Authorities or Regulated Entities (National IDs, Bank IDs, Tax IDs, Driver's License, Telephone Numbers) – Strong Proof of Identity Guidelines often defined by law/regulation

15. The IDs in 2 and 3 typically require entities to go through an in-person enrollment process which require the entities to establish their identity through a Proof of ID/Existence and/or Proof of Address. These generally form part of "Know Your Customer" (KYC) guidelines defined by regulatory authorities or the entities which use a service, such as a blockchain, to authenticate others.

16. Several countries have created digital ID systems that can be used by citizens to identify and authenticate themselves for transactions. These electronic IDs can take the form of a Smart Card (for ex: Estonia, Other countries in EU) or can be completely digital IDs (e.g. the AADHAAR ID in India).

17. There are a number of globally accepted systems, which deal with organizational identities such as proprietary systems, jurisdictional registration/incorporation number, tax registration number, etc.

18. These systems offer reliable means of verifying an organization's identity in online transactions. While some of these identity systems are based on voluntary registrations, others also are based on independent verification of public data that is available about an organization, thus making the identity more reliable.

19. Identity verification KYC guidelines and background checks are, therefore, critical in establishing reliable digital IDs that can be used when creating blockchain transactions that may require legal recognition. Since aspects of identity verification differ across countries, a common intergovernmental framework may need to be adopted to ensure cross-border acceptance of identity systems and documents implemented using blockchain technology.

20. A blockchain system could leverage digital ID systems with appropriate authentication mechanisms to identify individuals. By combining decentralized Blockchain principles with identity verification and cryptography, a digital signature can be created and

[2] The World Bank, 'Counting the Uncounted: 1.1 billion people without IDs' http://blogs.worldbank.org/ic4d/counting-uncounted-11-billion-people-without-ids (as of January 2019); See also ID 2020, 'ID 2020 Alliance' https://static1.squarespace.com/static/578015396a4963f7d4413498/t/5a1c456f8165f542d6d50813/1511802225611/ID2020+Alliance+Doc+-+Nov+2017+%281%29.pdf (as of January 2019).

assigned to every online transaction of an asset. This has several potential benefits for consumers, businesses and regulators alike.

21. First, creating an identity on a blockchain gives individuals greater control over who has their personal information and how they access it. Blockchain identity management platforms can also have the benefit of simplifying procedures associated with burdensome, costly and time-consuming KYC obligations as well as better complying with data collection and privacy regulations. For businesses, this could lead to stronger regulatory compliance, lower costs, reduced fraud[3], and a more seamless experience for clients. Similarly, for regulators, a standardized process allows for prompt auditing and increased efficiency in compliance control, monitoring and quality. Taken holistically, improved means of verifying and managing digital identities and personal information based on blockchain technology will increase transaction efficiency and further facilitate trade.

22. From a development perspective, digital identity secured by blockchain technology applications has the potential to give those 1 billion unidentified individuals access to a safe, verifiable, and persistent form of identity. More broadly, it could allow the 2 billion people who are unbanked to be included in labour and financial markets.

23. Blockchain facilitates immutable, secure, and privacy-respecting, sharing and validation of digital attributes for consumers and businesses. An intergovernmental framework may be required in the context of establishing standardization of entity information where multiple parties across different jurisdictions want to use a blockchain for verifying identities (for example authorities in an importing country and an exporting country may both want to verify the identity of the same manufacturer).

## C. Authentication and authorization

24. Authentication creates a link between a person (physical or legal) and the content (document, transaction, procedure or other). The link can be considered as having three inherent functions: an identification function, an evidentiary function and an attribution function.[4] The typologies of authentication include "What you know" such as passwords or pins and "What you have" such as biometrics.[5]

25. The identification function of authentication allows the establishment of the identity of the signatory. People might be identified by one or more of the following means. When more than one means is used this is commonly referred to as Two Factor or Multi Factor Authentication. Some examples of authentication typologies include:[6]

- Username and password;
- Grid cards, images, knowledge bases;
- Fingerprints or IRIS scans;

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[3] In Australia, it was found that the e-commerce merchants currently lose between one and five per cent of revenue to fraud and that across all sectors, compromised security contributes to AU$2.4bn in fraud every year. See, Australia Post, 'A Frictionless Future for Identity Management: A practical solution for Australia's digital identity challenge' (December 2016).

[4] See UNECE Recommendation 14: Authentication of Trade Documents, 2014: http://www.unece.org/fileadmin/DAM/cefact/recommendations/rec14/ECE_TRADE_C_CEFACT_2014_6E_Rec14.pdf (as of January 2019). Also see UNCITRAL "Promoting Confidence in Electronic Commerce: Legal Issues on International Use of Electronic Authentication and Signature Methods", United Nations, Vienna, 2009, page 5: http://www.uncitral.org/pdf/english/texts/electcom/08-55698_Ebook.pdf (as of January 2019).

[5] Op. Cit. UNECE Recommendation 14 – see annex B.2.

[6] Op. Cit. UNECE Recommendation 14 – see annex B.2 for a more complete list.

- One-time pin sent to a mobile number or other device;
- Social network-based access; or
- Digital certificates issued in the name of the user.

26. Blockchain-based authentication can leverage any of the above authentication methods based on the level of reliability required by those parties using the blockchain network for authentication.

27. Blockchain-based distributed ledgers store replicated data about transactions across many nodes. That data may include small programs called smart contracts with rules that are applied to future transactions but, a blockchain does not provide an interface for users to interact with it or – with the exception of some smart contracts – decide what transactions are written. Therefore, an application layer is needed such as wallet software or other domain-specific applications in order to drive user interactions with a blockchain. This means that the authentication used in a blockchain-based system will be driven by the application software which may be designed to leverage any of the authentication methods indicated above.

28. In a decentralized (blockchain) system there are no recognized governmental or intergovernmental authorities. As a result, an intergovernmental framework may be needed for the cross-border acceptance by authorities (for example courts) of blockchain data. Such a framework could, for example, define required levels of governance and accountability in cases where credentials (i.e. means of authentication) may be compromised.

29. Authorization refers to the process of giving user consent to implement a transaction. This could be a payment transfer or an action as part of a business application that could be coded into a smart contract.

30. This consent is typically given using a clickable “OK” or “I accept” box as part of an application workflow. To establish transaction integrity, blockchain-based systems could also make use of digital signatures that use asymmetric key-pairs where a private key is used to encrypt the hash of the data which is decrypted using the public key. This technique is used to ensure that data cannot be altered during its communication as any change in the data will result in an invalid transaction signature.

31. To further tamper-proof transaction information, blockchain-based systems leverage cryptographic hashes through which sequential transactions are linked together and any attempt to alter any record will require access to private keys and alteration of the entire chain (which is stored on multiple nodes), which is extremely difficult and, depending upon the type of consensus mechanism used and number of nodes, can be almost impossible.

## D. Data integrity and time stamping

32. From a data, integrity and redundancy standpoint, a centralized ledger (database) can be lost or destroyed and it must be regularly backed up. Transactions recorded in a ledger must be validated in order to be considered authentic. The ledger must also be reliable to have recorded all valid transactions completely, accurately and only once. If historical transactions are altered, users must be able to ascertain that changes were made for bona fide reasons and ensure that an audit trail was created so that transaction integrity can be verified.

33. Because blockchain ledgers are copied across many nodes within the blockchain network, these risks are mitigated. This is achieved through the use of distributed consensus mechanisms. New records are only added after they have been agreed to by the majority of participants in a Blockchain. New users receive a copy of the entire blockchain and all copies of blockchain ledgers are updated with new transactions as they are created.

34. Invalid blocks of data are detected and rejected through a mechanism of mathematical consensus such as proof of work. The difficult to create/ easy to verify principle behind blockchain consensus mechanisms ensure that invalid blocks can be detected quickly.

35. At any point in time, the integrity of a blockchain ledger can be verified by re-computing the current state of the ledger (represented by a cryptographic hash number) by starting from the beginning (called the genesis block) and re-calculating the cryptographic hashes for each block of transactions, in sequence, going forward to the current transaction block.

36. Further, data authenticity on a blockchain ledger is ensured through the use of time stamping techniques. A digital, trustworthy timestamp can be used to prove the non-existence of certain data before a given point in time without the possibility of anyone being able to change or the timestamp. Timestamps are taken by a blockchain from a trusted third party using a reliable time source such as an atomic clock.

37. A transaction is normally saved on a blockchain with both a time stamp and the digital signature of the entity or process initiating the transaction. The time stamp is hashed and digitally signed by the time stamping authority's private key.[7]

38. Because this hash and timestamp are stored on a distributed blockchain ledger where consensus on the validity of the time is established without relying on a central authority (i.e. without a single point of failure that, if hacked could result in false data); the timestamp can be verified, with a very high degree of trustworthiness, to ensure that the document was not backdated.

39. Data written to a centralized ledger can be censored/tampered with in order to filter, permit and prioritize transactions based on political and malicious interests, thus prohibiting certain people to perform transactions on par with others. Since transactions in a blockchain system can be processed from any participating node/server, there is no single centralized server which can impose censorship or apply prioritization rules to transactions.

40. Each node creates new blocks based on the information available to it at the moment. Because of network latency, whereby nodes may receive information at different times, this can result in different nodes publishing different blocks at the same time, without this being caused by errors or inaccurate data. This can, temporarily, result in differing versions of a blockchain ledger existing which is called a "ledger conflict". For example, in a blockchain-based digital currency system, the same money could show as spent and unspent, depending on at which blockchain ledger version we were looking. However, these conflicts are resolved automatically as the longest chain available becomes the official blockchain. Any data that was in a shorter block and is not included in the longest, selected block, is returned to the unused transaction pool to be included in a later block.

41. Because of the possibility of ledger conflicts resulting in a processed transaction being returned to the unused transaction pool (because the block it was included in turned out not to be the longest one), a concept called confirmations is used by users to measure the probability of a transaction being permanently present in a blockchain. A transactions confirmation is the number of blocks present after the block where the transaction is found. For example, in the Bitcoin network 6 confirmations are considered very safe as it would be extremely difficult for so many blocks to be rejected due to ledger conflicts or for a forking to happen before the block containing the said transaction if it is followed by six new valid blocks. The number of confirmations considered to ensure that a transaction is safe is different for different protocols based on the block creation time and whether the blockchain is permissioned or permission less.

[7] These processes are defined in the Internet Engineering Task Force standard RFC 3161 and the ANSI ASC X9.95 standard

42. While blockchain-based distributed ledgers provide transaction immutability, there is also almost no way to remove inaccurate data if it was erroneously entered in the first place. For this reason, it is important to put logic into blockchain-based applications and smart contracts which allows for new transactions to be entered that will, in effect, erase the impact of previous inaccurate entries (even though the inaccurate entries remain – just like in a paper-based ledger accounting system).

43. Reversing transactions requires a fork (a fork results in two blockchains, one being the modified blockchain and the other, if it has nodes which continue it, being the original blockchain up until the moment of forking). A fork requires that the change has to be approved by the majority of mining nodes before any published blocks are rewritten. In permission less blockchains where the number and identity of participating nodes is unknown and there is no common agreement on rules to govern forking this can be close to impossible. In permissioned ledgers, where the identity of participating nodes is known and they may have signed an agreement regarding governance and forking, this may be easier....

44. The only way that data on blockchain systems can be altered is if users are able to secure over 50 percent of the processing power or a majority stake (depending upon the consensus process used). Such hijacking of a blockchain is called a 51% attack and can result in:

- Not recording transactions from specific users, nodes, suppliers or even countries;
- Creating an alternate chain that is longer than the original chain which nodes will switch to because they will automatically think that the longer chain has had the most verification work done to it; and
- Disrupting how and where information is distributed by thwarting or not transmitting blocks to other nodes.

45. While in theory blockchains are vulnerable to cyberattacks including Sybil (identity theft) attacks and distributed denial of service, the combination of decentralized database architecture, cryptography and the principles of immutability and consensus that makes blockchain-based distributed ledgers resilient to cyber-attacks. by virtue of this design, the probability of a successful attack is reduced as a large number of nodes would have to be compromised. The types of attacks that a blockchain is susceptible to depend upon a range of characteristics. For example, blockchains with fewer nodes are at a greater risk for 51% attacks, while permission less blockchains may be more at risk of identity theft than permissioned blockchains where access is more restricted.

## E. Privacy, confidentiality, accessing and sharing of information

46. Confidentiality refers to the protection of data shared between an entity (i.e., individual or organization) and an authorized party from unauthorized third parties. Privacy refers to protection from intrusion into one's personal identity and personal transactions. Digital innovations, including blockchain technology, may have the potential to protect rights of citizens including privacy and confidentiality.

47. In many cases, confidentiality and privacy are enforced by legislation (e.g. EU data protection legislation), regulation (client confidentiality) or contract (commercial confidentiality). As such, it is critical to understand how blockchain technology impacts upon these protected rights.

48. The design of any digital platform for trade facilitation using blockchain technology must be done so as to store and transmit data in a way that safeguards the right of individuals to confidentiality and privacy. To achieve this, it may be necessary for developers to only record hashes of personal data on the blockchain and to not store any private data on the

blockchain. Instead, private data can be stored off-chain and only exchanged as needed and in peer-to-peer communications.

49. For example, an individual who needs to prove they have a driver's license for the purposes of employment can have their claim of having a license verified by an authorized third party (e.g., the relevant motor vehicle licensing department). The authorized third party could then digitally sign the claim and produce a cryptographic hash of the verified claim which is then saved on the blockchain. The employer could then compare the hash to a copy of the claim with the electronic signature (to ensure that it is valid and not a forgery). This allows an individual to assert they have a driver's license without revealing any other personal information. The use of zero-knowledge proofs[8] can add further privacy to personal data, by using mathematical proofs to demonstrate the validity of information without revealing the underlying personal data.[9] For example, zero-knowledge proofs can show that an individual is over 18 without revealing their specific age, or that they live in Paris without providing their address in Paris.

50. The following rules should be considered when designing blockchain systems that need to safeguard privacy and confidentiality:

- Transacting parties cannot be identified by an unauthorized third party from the information stored on the blockchain (including metadata)[10], unless the party(ies) to be identified has/have chosen to reveal that information;
- Other transaction details are not visible to unauthorized third parties and to the open public unless one of the transacting parties has elected to disclose that information; and
- Transaction details cannot be collated, analyzed or matched with *off-blockchain*[11] meta data to reveal any information about the transacting parties or the details of the transaction.[12]

51. Blockchains, as distributed public ledgers, are not inherently respective of privacy and confidentiality.[13] Indeed, the two largest blockchain system, Bitcoin[14] and Ethereum[15], are public, open, transparent, and pseudonymous. They are open in the sense that there are no

[8] A zero-knowledge proof is a cryptographic technique which allows two parties (a prover and a verifier) to prove that a proposition is true, without revealing any information about that thing apart from it being true.

[9] See Daniel Augot et al., 'Transforming face-to-face identity proofing into anonymous digital identity using the Bitcoin blockchain' (International Conference on Privacy, Security and Trust, 2017) https://arxiv.org/pdf/1710.02951.pdf (as of January 2019).

[10] This includes the time the transaction was executed.

[11] Off-blockchain transactions are transactions that are recorded on an internal ledger which are occasionally synchronized with the blockchain. For example, Coinbase, a cryptocurrency exchange service, maintains an internal ledger for its clients as they make transactions and later broadcasts those transactions to the blockchain.

[12] See Danny Yang, Jack Gavigan and Zooko Wilcox-O'Hearn 'Survey of Confidentiality and Privacy Preserving Technologies for Blockchains' R3 Reports November 2016 https://www.r3.com/wp-content/uploads/2017/06/survey_confidentiality_privacy_R3.pdf (as of January 2019).

[13] See, generally, Primavera De Filippi, 'The Interplay between Decentralization and Privacy: The case of blockchain technologies' (2016) 7 Journal of Peer Production 1 <https://hal.archives-ouvertes.fr/hal-01382006/document>. See also Morgan Peck, 'Cheat Sheet: The trade-offs of blockchain privacy tools' 8 March 2019 American Banker https://www.americanbanker.com/news/cheat-sheet-the-trade-offs-of-blockchain-privacy-tools (as of January 2019).

[14] Satoshi Nakamoto "Bitcoin: A Peer-to-Peer Electronic Cash System" (2008, Bitcoin White Paper): https://bitcoin.org/bitcoin.pdf (as of January 2019).

[15] Vitalik Buterin, "A Next Generation Smart Contract and Decentralized Application Platform" (2015, Ethereum White Paper): https://github.com/ethereum/wiki/wiki/White-Paper (as of January 2019).

restrictions on participation (i.e., they are permission less blockchain systems) and they are transparent because all transaction information is visible to anyone on the blockchain. In addition, all transactions are openly visible to all network participants. Moreover, on the Ethereum blockchain, the code and execution of smart contracts is also visible.

52. In both blockchains, transacting parties are pseudonymous and identified by public keys generated using mathematically derived algorithms (known as Bitcoin addresses or Ethereum accounts). This provides only a very limited amount of confidentiality, because it is possible to connect the identity of an individual with their public key.[16] For example:

- Some people share their address publicly so that other parties may transact with them and, as a result, none of their transactions using that public key (past or future) can be confidential.
- Cryptocurrency exchanges[17] require the verification of physical identity documents in order to join, allowing them to link one's real identity with their public key.
- There are companies making a business from linking identities to addresses and creating commercialized databases that track all Bitcoin activity in an effort to de-anonymize Bitcoin.

53. Because transactions made on blockchain are fully traceable[18], once a person's identity has been linked to their public key it is possible to infer and monitor an individual's spending patterns (such as where they spend, how much they spend, and how often), their wealth and income, and with whom they undertake transactions. It is also important to remember that the data written to the blockchain is immutable and irreversible, meaning it is permanently accessible and visible. As such, incursions on one's privacy or confidentiality cannot be reversed or corrected at a later time.

54. Some blockchain developers, having recognized the issues associated with privacy and confidentiality, have taken steps to address them by creating platforms that do not make publicly available transactional details, thereby retaining transactional privacy.[19] Indeed, the lack of guaranteed privacy has been identified as hindering the broad adoption of decentralized smart contracts because parties to financial transactions, such as the trading of insurance contracts or company shares, require that those transactions be kept private.

55. At the same time, for international cross-border transactions, it remains important to engage with intergovernmental bodies in order to secure harmonized workable systems that are accepted from a legal standpoint.

[16] See Elli Androulaki et al 'Evaluating User Privacy in Bitcoin' (2012) 7859 Lecture Notes in Computer Science 1 https://eprint.iacr.org/2012/596.pdf (as of January 2019). In this study, it was concluded that the profiles of almost 40% of Bitcoin blockchain users can be determined even when users adopt privacy measures recommended by Bitcoin.

[17] Popular exchanges include Coinbase https://www.coinbase.com/ (as of January 2019), Kraken https://www.kraken.com/ (as of January 2019) and Gemini https://gemini.com/ (as of January 2019).

[18] Indeed, a bitcoin is defined as the history of its custody - "an electronic coin as a chain of digital signatures". Satoshi Nakamoto, above n 30, 2

[19] See, generally, Danny Yang, Jack Gavigan and Zooko Wilcox-O'Hearn, above n 26. https://z.cash/static/R3_Confidentiality_and_Privacy_Report.pdf (as of January 2019).

## F. Legal aspects

### I. Admissibility of electronic evidence

56. In an article by Donald Zupanec[20], The American Law Report lists some ways to establish a comprehensive legal foundation. It suggests that the proponent demonstrate "the reliability of the computer equipment", "the manner in which the basic data was initially entered", "the measures taken to ensure the accuracy of the data as entered", "the method of storing the data and the precautions taken to prevent its loss", "the reliability of the computer programs used to process the data", and "the measures taken to verify the accuracy of the program"

57. Guidelines issued by the Association of Chief Police Officers (ACPO) for the authentication and integrity of evidence are widely accepted in courts of England and Scotland. These guidelines consist of four principles:

- No action taken by law enforcement agencies, persons employed within those agencies or their agents should change data which may subsequently be relied upon in court.
- In circumstances where a person finds it necessary to access original data, that person must be competent to do so and be able to give evidence explaining the relevance and the implications of their actions.
- An audit trail or other record of all processes applied to digital evidence should be created and preserved. An independent third party should be able to examine those processes and achieve the same result.
- The person in charge of the investigation has overall responsibility for ensuring that the law and these principles are adhered to.

58. Countries with Civil Law systems are usually less restrictive about what evidence can be used since they rely on the probative value of the evidence as determined by judges. Hence there is not too much distinction between evidence and electronic evidence. In Spain, the Criminal Procedure Law includes among the modes of evidence the means of reproducing words, sounds and images as well as instruments permitting the filing and knowing or reproducing words, data, figures and mathematical operations carried out for accounting purposes or other ends, relevant to the trial.

59. Furthermore, in the enumeration of the different formats that can be considered a document under the Criminal Code any format containing data is included. Finally, in Spain, the Labour Proceedings Law allows the use of any type of evidence, including mechanical means of reproducing words, images and sounds

60. In addition, there are some guidelines for the steps for collecting and usage of electronic evidence namely:

- Obtaining the evidence (to be done legally);
- Incorporating the electronic evidence into process (relevance & necessity, legality and compliance with admissible procedures);
- Evaluation of the electronic evidence by the judge (challenge, authenticity and integrity): The self-assessment by the judge includes authenticity of the origin and data should not have been tampered.

[20] Zupanec, Donald 1981-01-01 "Admissibility of Computerized Private Business Records", American law reports. alr 4th. cases and annotations. 7. pp. 16–19)

61. To resolve a dispute, whether relating to a civil or criminal matter, in any court the parties will have to prove many issues with materials to substantiate the facts. The law must ensure certain guidelines are followed to ensure that evidence presented to the court can be regarded as trustworthy and relevant. The general rule in evidence is that all relevant evidence is admissible, and all irrelevant evidence is inadmissible. The law of evidence, also known as the rules of evidence, encompasses the rules and legal principles that govern the proof of facts in a legal proceeding. Every country has enacted a law of evidence.

62. The legal system, therefore, expects a certain degree of authenticity, immutability and auditability of the material or data presented in order for the courts to consider them as admissible evidence. In the case of a public blockchain ledger, although the technology provides for the immutability and auditability of transactions, the network allows anyone to participate, using pseudonyms, which makes it very complicated to assess the legal identity of the person(s) participating in a transaction. Thus, unless the person(s) participating in the law suit are mandated to identify the true identity of the participant(s) in the transactions on the public blockchain which are in question, the legal system or the courts may have concerns about blockchain-based transactions being admissible evidence.

63. In the case of private or permissioned ledgers, blockchain technology provides for the immutability and auditability of transactions entered by the authorized parties and, thereby, satisfies the requirements of legal systems for considering digital evidence as being valid. In addition, the tamper proof nature of data recorded using blockchain technology, usually in a chronological order and/or with time stamps further enhances the reliability of and authenticity of the recorded transactions, thus lending credibility to, and increasing the admissibility of, the electronic data being submitted as evidence.

64. However, in some countries evidence law prescribes specific conditions for establishing the legal validity of electronic data, such as the authentication of electronic transactions using certified electronic/digital signatures. Blockchain, in general, uses cryptography key technology that is similar to Public Key Infrastructure (PKI), the technology used in digital signatures. Therefore, the digital signatures used in blockchain may already be compliant with local laws[21], thus making blockchain transactions legally valid for the purpose of admissibility.

## G. Non-repudiation

65. The evidentiary function of a signature involves legal implications and can include integrity, consent, acknowledgement…[22] Non-repudiation refers to the author of a statement or a signatory to an agreement not being able to successfully deny the authorship of the statement or the validity of a contract they previously agreed to and/or signed.

66. The process of establishing non-repudiation depends on the local laws of countries and their recognition of what constitutes a framework under which an electronic record can be considered secure and, therefore, cannot be repudiated. Some of the security procedures that concerned parties could undertake in order to better establish a status of non-repudiation include the ability to:

- Verify that the electronic authorization used in a transaction is unique to the user performing the transaction and it is capable of identifying such user
- Validate the fact that the electronic authorization was created in a manner or using a means which was under the exclusive control of the subscriber

[21] This needs to be verified on a case by case basis
[22] Op. cit. UNECE recommendation 14, page 5

- Verify that the method of electronic authorization is linked to the electronic record to which it relates in such a manner that if the electronic record was altered, the method of electronic authorization would be invalidated

67. In the context of blockchain systems, the admissibility of electronic evidence may be based on the ability to establish the non-repudiation of transactions which in turn depends on the security measures that are put in place under which data integrity, confidentiality, privacy and authenticity of transactions can be established.

## H. Dispute Settlement and Enforcement

68. Experience has shown that public blockchains often have governance problems when trying to change their operating rules (for example, in order to reduce energy consumption or increase a blockchain's ability to process large volumes of data faster) due to conflicts between developers and node operators. These conflicts do not directly impact the legal issues discussed here, but may, over the longer term, undermine the democratized trustworthiness created by blockchain technology and hinder its broadening evolution and applicability.

69. At the transaction level, the applied consensus mechanism used by a blockchain allows participants, as a group, to challenge the outcomes from smart contracts and transactions (based on the rules set out by the blockchain and the recorded transactions). On the other hand, there is no method available for a participant to challenge the business outcome arrived at by a smart contract if, for example, the outcome (after a correct execution of the contract) is not what the participant expected when agreeing to the original terms of the smart contract.

70. A contract is a legally enforceable agreement. Smart contracts are computer programs that execute when previously agreed upon conditions are met. In spite of their name, this does not, necessarily mean, that they represent a legal contract. They are only contracts if and when they are the source of an obligation that is clearly understood by the parties involved. On the other hand, they are not a contract if they are only a method for executing an obligation that has its origin elsewhere. For example, a smart contract is not a contract if it implements the terms of an insurance contract which was signed on paper and may cover thousands of instances of smart contract execution (for example an insurance policy covering all the containers shipped by one multi-national). Once written onto a blockchain, a smart contract cannot be changed, and its execution cannot be stopped (once the pre-defined conditions are met). Therefore, if a smart contract is well designed and coded correctly, the non-performance of the contract is not possible. However, there could be problems linked to incorrectly coded smart contracts, false representation of the results of smart contracts, etc.

71. A contract is an agreement and legally requires parties to the contract understand clearly what they have agreed to. Where consumers are involved, particularly Micro-, Small- and Medium-Sized Enterprises (MSMEs), interaction with a smart contract usually takes place via a user interface which is likely to have been developed by the creator of the smart contract in question. Therefore, what is most likely to be considered by a court as being the legal agreement is the offer presented via the user interface to other participants by the creator of the smart contract. The smart contract itself is code that cannot be easily understood by humans (and which may or may not correspond to the information presented by the user interface).

72. Even when a smart contract is not a contract (which is most of the time), it can still have a legal impact or meaning. Among these other legal acts or meanings are:

- Execution of a contract;

- Suspensive or dissolving condition in a contract (i.e. if X is true, then the contract will not execute);
- Unilateral legal act;
- Decision under public law;
- A means of evidence;
- Obligation of compliance with a (fiscal law); and/or
- Others, depending upon the jurisdiction in question.[23]

73. One novel issue related to the use of smart contracts is what happens when an agreement cannot be enforced or its enforcement cannot be stopped by public law enforcers, but only through the terms and mechanisms set forth in a computer program (i.e., smart contract) that cannot be changed. The typical legal action for breach of contract involves an aggrieved party going to a court of law or an equivalent, for example a mediator, to demand monetary damages, restitution, or specific performance. With a smart contract, the aggrieved party will need to go to the court to seek a remedy to a contract that has already been executed or is in the process of being performed. Therefore, the remedy will need to come after the fact in order to undo or alter the agreement in some way.

74. Assuming the parties to a given smart contract are known, courts could require the parties to create a new transaction to reverse the undesirable outcomes of the coded and executed smart contract under dispute. This is a possible solution because courts will not be able to affect the initial outcome of a disputed smart contract transaction and a retroactive change in a blockchain is not possible, at least from a practical standpoint.[24]

75. The ability to enforce the agreements represented by smart contracts via traditional legal means is limited. First, disputing a smart contract with traditional means (in court, arbitration, mediation, etc.) is only possible when the identity of the parties involved is known. Because of the anonymity[25] of most public blockchain transactions this may not be possible. Moreover, while smart contracts are coded as self-executing contracts, if the end result requires actions that cannot be taken directly by the smart contract using the blockchain network or the Internet, but rather requires human intervention (for example, the physical transfer of property), the smart contract does not provide effective mechanisms for enforcement if one party breaches his or her obligations. While, semantically, it might be argued that breach of a smart contract is not possible because the contract simply will not execute if a parameter is not fulfilled – this may depend upon the smart contract being able to finish execution without any human intervention which may not always be the case.

76. When a smart contract replaces an existing legal contract, in the majority of circumstances, the smart contract will be governed by the same legal principles as would the similar paper-based legal contract – if the smart contract is a commercial transaction and all of the parties to the smart contract are known. Even when all of the parties are not in the same legal jurisdiction, there exists well established principles in international commercial law for establishing the applicable jurisdiction and law. If the identities of the contracting parties are not known to one another and the blockchain in question is a private or permissioned one, the operator of the blockchain platform should have a legal obligation to identify who the breaching party was in a dispute scenario where a breach can be shown to have taken place.

[23] The Legal Aspects of Blockchain, UNOPS, 2018, Page 90

[24] As discussed earlier, it is theoretically possible to change information (including smart contracts) on a blockchain, but in practice it is nearly impossible

[25] As discussed earlier, some public blockchains offer complete anonymity but the most important ones offer only the privacy provided by "pseudonyms". While the owners of pseudonyms can be identified (but not always), it is still difficult to do so. As a result, most transactions are, in practical terms, anonymous.

77. In anticipation of possible disputes, the operators of permissioned blockchain systems may want to establish governing rules for their blockchain and specifications for dispute resolution. However, these specifications would have to be disclosed upfront and agreed upon by the parties to the smart contract in order for them to be enforceable.

78. Courts may be substantially challenged in interpreting smart contracts. Unlike the interpretation of a contractual dispute in the existing legal infrastructure where courts assess what the contentious language in a given contract may mean to a reasonable human observer, smart contracts are not coded for a human observer. Rather, they are intended for execution by computers on a network of blockchain nodes and in the future, they may even be created by artificial intelligence.

79. To the extent that consumers interact with smart contracts, the graphical user interfaces which they use for this purpose should provide courts with information about what the consumer could have reasonably expected from the execution of a smart contract. From a business standpoint there are also communications between business actors and programmers regarding what a smart contract should be developed to do. This second context, however, opens up thorny questions regarding the legal liability of programmers for the consequences of mistakes, even if they are honest mistakes, in smart contracts – and of businesses for mistakes which may be made by artificial intelligence systems that they deploy, and which may develop smart contracts.

80. The basic premise of smart contracts is computer programming not human interaction and in the future, some smart contracts may be developed by automated systems to regulate interactions between inanimate objects (for example, between solar panels and electrical grids). Because of the emphasis on computer programming and artificial intelligence, courts may not be able to evaluate for themselves the quality of smart contracts (i.e. evaluate if they were developed with appropriate due diligence). Courts may also be limited in their ability to consult programmers to interpret code in a given case because the meaning and logical reasoning of computer code is substantially different from human language.

81. In the cases where the identities of the participating parties to a smart contract are not known, from an identification perspective, it is unclear who would own the output/data created by the smart contract in question and whether there would need to be any applicable protections, such as for work products or confidentiality. Without knowing the ownership rights for a blockchain transaction, it is also unclear who would be able to claim privileged information or how discovery would operate via existing laws.

82. However, when the parties to a smart contract choose to reveal their identities, arguably privileged information and/or discovery laws should apply as if the smart contract was a written contract, despite the fact that the contract/agreement takes the form of computer code.

83. While international commercial law would normally be applicable when the parties are known, not all contract law remedies may apply to smart contracts which raises possible enforceability issues. If a transaction in a smart contract fails to be completed (for example because some required input cannot be given) or is only partially completed, it is unclear how liability will be allocated if those eventualities have not been taken into account in the development of a smart contract's code and/or any associated agreements. Because of the decentralized nature of blockchain, it may unclear who or what is accountable for the failure of the contract. Guidelines for the application of existing contract law to disputes involving blockchain smart contracts may be useful. As jurisprudence is developed, the need for additional legislation may also be identified. Without such guidance, the liability for failed transactions or conflicts between parties to smart contracts will present unique challenges to judicial systems.

84. This rest of this section aims to address four aspects of contract law in the context of blockchain-based distributed ledgers

- Formation;
- Performance;
- Breach & remedies;
- Input error issues.

## I. Formation

85. Before any new contract can operate, two parties must agree to some set of terms that initiates the program. This will come through an offer and acceptance. In the realm of smart contracts, unlike traditional contracts, acceptance comes through performance.

86. An individual trader (buyer or seller) can initiate a smart contract by posting the relevant code to a blockchain. However, until the program initiates (is accepted by a counter party), there is no contract. This smart contract code which has been posted to a ledger can be seen as being an offer. Once an action is taken to accept the offer, such as a party transacting in a way that gives the code control over a certain amount of money, the contract is formed.

87. Smart contracts can be of particular value because they bind the hands of the executor, which is, in effect, the smart contract, to the original will of the testators (contracting parties), with little room for deviation. Although ambiguity certainly exists in programming languages, these ambiguities are less than in the real world because there are simply fewer terms that a computer can recognize than a human can recognize. Thus the problem of ambiguity is reduced in the smart contract context.

## II. Performance and modification

88. A contract can be performed, modified, or breached. The performance phase is made easier with smart contracts as they offer a tool to solve ambiguity problems as discussed above. However, there is a problem with regard to imperfect performance. Courts do not demand perfect performance for a contract to be recognized and enforced. The common law doctrine of substantial performance permits a contract to be recognized even if the performance does not fully conform with the express terms laid out in the contract. This is the kind of leeway that a computer program cannot recognize because it involves an outcome that was not contemplated and specified by the parties. One way that parties can deal with this is by incorporating a certain degree of discretion/flexibility into the terms of the contract initially – or by simply not using a smart contract if the ability to respond to unforeseeable circumstances is a necessary part of the contract.

89. There is also the problem of contract terms which diverge either accidentally or on purpose from what the law recognizes. In this case, the law would have to decide between ex ante and ex post solutions to the problem. Again, ex ante solutions will be difficult to implement because of the immutability of smart contracts.

90. For example, the law recognizes certain circumstances that will absolve a party from performance or require some sort of modification to a contract. Impossibility and impracticability are two such circumstances. In addition, when a contract becomes illegal after it is formed, then the parties can be excused from performance and there is generally no remedy for an aggrieved party.

91. This poses a problem for the smart contract. For example, suppose that at the time of contract formation, the time a debtor needs to be in default before the creditor can repossess the goods in question is 30 days and this is written into a smart contract. Then, after the

contract is executed, a legislature changes the law requiring that time period to be 90 days. There are numerous ways of addressing this potential situation, ranging from state-backed to purely private. One method could be a system in which the relevant jurisdiction creates a publicly available database, with an application programming interface (API), containing relevant legal provisions. These would be provisions related to the terms of a contract. The smart contract would call upon these terms and would be able to update those terms in the smart contract based upon the jurisdiction's update of the database.

92. Another method would be through ex post policing by the parties; this puts the burden on the parties or their agents to update the code. This can only be done in a smart contract by defining some terms as being variable and identifying the conditions under which they can be changed. For example, implementing a change might require electronic signatures from all parties involved. The benefit of this option is that there is no need to rely on a third-party government office to create a new infrastructure. The downside is that this requires parties to foresee the need for possible changes and for a smart contract to be designed in such a way that the parties must agree on changes and it is not possible to unilaterally change the terms of the contract. Such design also reduces the predictability/reliability of smart contract results, which is one of the principle benefits of using smart contracts. This reduction in predictability could be reduced by having certain terms of the contract be modifiable, while restricting others so that they cannot be modified. For example, the requirement for payment could be an immutable term, whereas the length of time a debtor has before he is in default could be modifiable.

93. Still another method, if the possibility of the change in question was not at all foreseen when the smart contract was developed, is to create a second smart contract that, in effect, reverses the action of the first contract. This would of course require all participating parties to agree.

94. Finally, computer programs and thus smart contracts can be written with the option of inserting code later. However, this raises all of the issues mentioned above concerning when and how such changes could be made without destroying the principle rationale (predictability and reliability) for the use of smart contracts.

## III. Enforcement, breach and remedies

95. The central problem for smart contracts in the context of contract law is: what happens when the outcomes of the smart contract diverge from the outcomes that the law demands? It is possible, and hopefully probable, that smart contracts will diverge less than written contracts from the desired legal outcomes, not the least because of reduced ambiguity and increased difficulties in breaching a contract because participants cannot influence the smart contract after it has been established. Courts will probably be more likely to enforce smart contract terms because the courts will have more certainty as to the parties' intent because the parties had to explicitly lay out their terms in advance. Because of their inflexibility, smart contract drafters are going to be more likely to write smart contracts that conform with existing law and to write smart contracts with terms that are variable in order to accommodate future changes in the law or use of the same smart contract by participants in different jurisdictions. The terms of a lease, for instance, will change to accommodate the property law of the jurisdiction where the property is located. Additionally, it is possible that torts will emerge for negligent coding or negligent updates which would further ensure that future smart contracts are drafted in accordance with existing legal standards. But what happens when these forces are not enough and there is still divergence?

### IV. Input error issues

96. Like other systems, blockchain-based systems cannot attest to the accuracy of input data and errors in this data would influence the outcome of an autonomous smart contract's execution.

97. While errors can be handled between parties using a reversal transaction, as in a paper-based accounting ledger, courts of law may also need to have provisions to handle these issues related to erroneous input to smart contracts.

## I. Mutual recognition

98. As the number of use cases for blockchain expands, the number of parties using the same blockchain-based applications and smart contracts who are located in multiple jurisdictions will also grow. As a result, complications will also increase which are related to enforcement in different jurisdictions where identification, authentication, non-repudiation standards are driven by local laws and regulations. Many of these can be resolved on the basis of existing international commercial law practices, especially when the parties to a transaction are known. At the same time, while blockchain applications provide increased certainty in some areas such as contract execution, they can also increase ambiguities and create new problems in other areas such as the identity of smart contract participants on public blockchains or, in some cases, applicable law. There will also be cases where international commercial law cannot be applied (for example, when blockchain use involves business to government communications and/or assets, such as land, which are covered by local laws).

99. To give electronic transactions which are used across jurisdictions or involve participants from different jurisdictions the same effect as paper-based transactions, mutual recognition frameworks need to be created which will allow parties in different jurisdictions to execute valid contracts on a blockchain or using other electronic technologies. These mutual recognition frameworks are especially needed for government to business communications and may take into account the functions of authentication: identification, evidentiary and attribution.[26]

100. Depending on the content of a contract and applicable law, mutual recognition frameworks may allow parties to a contract to decide what constitutes a valid transaction. Member states may also mandate guidelines or rules defining the process and procedure to be followed when validating and accepting a transaction from another jurisdiction. These guidelines and rules could be based upon, or drawn from, existing treaties and agreements between member states. The UN/CEFACT White Paper on Trusted Transboundary Environment may provide such a framework.[27]

## J. Legal aspects – conclusions

101. The above discussion on the legal aspects of smart contracts highlights the need for foresight and careful planning in order to avoid possible legal pitfalls. Among some of the more important actions that smart contract developers and implementors should consider are the following:

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[26] Op. Cit. UNECE Recommendation 14.

[27] See UN/CEFACT "White Paper on Trusted Transboundary Environment: Ensuring legally significant trusted trans-boundary electronic interaction," 2018: http://www.unece.org/fileadmin/DAM/cefact/cf_plenary/2018_plenary/ECE_TRADE_C_CEFACT_2018_7E.pdf (as of January 2019)

- Identification of variables that might change and methods for changing the variables without undermining the predictability and reliability of the underlying smart contract (for example, the requirement of multiple electronic signatures in order to make changes);
- Identification of inputs where the possibility of errors exist and a plan for identifying and fixing them;
- Identification of where, at some point in time, a selected oracle might cease to exist or fail due to government re-organization, bankruptcy, etc., and backup plans for their replacement if needed;
- Identification of any instances where a smart contract might not finish execution (for example because a required input is not received or not received within allowed time limits) and how such situations should be resolved;
- Designation, in advance and in a document separate from the code in the smart contract, of the
    - Applicable law;
    - Jurisdiction under which disputes should be settled;
    - Method of dispute resolution to be used;
    - General terms and conditions.

# Section II: Supply chain transparency

## A. Introduction

1. According to a 2018 article published by Supplychain247.com[1], the total value of goods shipped annually has reached 4 Trillion USD. Approximately 80% of this occurs in supply chains that require cross-ocean transportation. Although supply chains have embraced technology to achieve improved levels of efficiency, accuracy and value creation, they are by no means as efficient, accurate or value creating as most stakeholders would like. Some suggest that the global supply chain has not experienced significant disruption since the introduction of the standardized shipping container in the 1950's. A commonly cited figure in supply chain costing is that documentation costs can exceed the costs incurred in physically moving the products – in other words, documentation management can double the cost of the process.

2. In a whitepaper written for the 2017 World Economic Forum[2] in Davos, Switzerland, BVL International states that 85.5% of the surveyed logistics business predicted a positive impact to costs, revenues, or both, from future digital transformation. It is expected that blockchain implementations could play a significant part in that digital transformation.

3. How can blockchains help supply chain stakeholders to save money and drive revenue? In one word, trustworthiness. Even a brief examination of current supply chains exposes the reliance on third parties (e.g. notaries, brokers, agencies, banks, certifying bodies) to establish trustworthiness between parties that cannot implicitly trust one another without such support. The need to establish trustworthiness creates inefficiency and waste. Where trustworthiness is weak or broken there is the potential for and, therefore, very often the reality of fraud. With 3.2 trillion USD worth of goods being shipped over extended supply chains these inefficiencies and risks become significant.

4. There are a wide range of stakeholders in a typical international supply chain that need access to information at some point during the movement of the traded goods between seller and buyer. For example:

- Those directing the transport and cargo processes (freight forwarders, shipping agents, forwarding agents, consignors/consignees);
- Transport operators (maritime, road, rail, barge, airlines);
- Port operators (terminal operators, warehouse storage keepers);
- Government agencies (customs, veterinary, police, ministry of transport/health/ environmental protection, port authorities, emergency services, etc.);
- Inspection authorities (surveyors, pest control, phytosanitary); and
- Supporting financial services (banks, insurance companies).

5. Blockchain offers the potential for improving the dependable accuracy of information, for speeding up and controlling access to that information.

6. Trustworthiness between parties can be established by ensuring the availability of trustworthy information which focusses on two main components of the transaction: the

[1] http://www.supplychain247.com/article/maersk_ibm_to_form_joint_blockchain_venture (as of January 2019)
[2] http://www3.weforum.org/docs/WEF_Impact_of_the_Fourth_Industrial_Revolution_on_Supply_Chains_.pdf (as of January 2019)

transparency with which business is conducted and the traceability of the product throughout its lifecycle.

- Transparency allows stakeholders to see into the process easily and accurately in order to receive accurate information in a timely manner; and
- Traceability allows stakeholders to know with confidence the relevant sources of any product in the process.

7. The two are intimately linked but are not synonymous. Increased transparency and traceability in the supply chain would allow stakeholders to realize the following benefits without, necessarily, incurring commensurate increases in costs:

- Speed;
- Accuracy;
- Efficiency;
- Increased granularity of historical data;
- Real time monitoring;
- Proof of provenance;
- Increased compliance; and
- Consumer/Customer engagement.

8. The World Trade Organization has estimated that reducing the friction in current systems, especially at the borders could increase global GDP by 0.5% and increase international trade, with particular benefits to developing countries.[3]

9. This section addresses the opportunities offered by blockchain technologies in addressing gaps in transparency and how it can support meeting the United Nations Sustainable Development Goals (SDGs) through improved traceability of materials. It also looks at the key challenges that implementers will have to overcome in order to realize the benefits of blockchains.

## B. Current challenges faced by modern supply chains

### I. Proof of provenance

10. At present, many transactions take place on the basis that the goods supplied are of a reported quality or are of a specific provenance. Currently, buyers have no cost-effective manner of verifying the authenticity of the suppliers' claims. This increases reliance on long-term and large contracts with established players and creates natural barriers to entry for new and smaller suppliers – and this, in turn, damages true competition.

11. Despite this, fraud based on passing off non-organic food as organic or even manufactured food (e.g. rice) as naturally grown is a big business. Food fraud is estimated to cost the world's economy $30-40Bn per year.[4]

12. With respect to the UN's SDGs, below are some examples of where increased traceability would have a long-term positive impact on the goals:

- SDG 1 – No Poverty. Items can be traced back to source and each stakeholder can be required to prove that they are not using child labor and/or are paying their workers a

[3] https://www.wto.org/english/tratop_e/tradfa_e/tfa_factsheet2017_e.pdf (as of January 2019)
[4] https://fas.org/sgp/crs/misc/R43358.pdf (as of January 2019)

living wage. Not every supplier will be able to prove this. These gaps in traceability will help authorities and buyers to identify bad or slow actors in this regard. Suppliers who are unable to meet the certification/traceability requirements should, in theory, begin to see less demand for their products.

- SDG 6 – Clean Water and Sanitation. At present, once it has entered the supply chain, a leather hide that was tanned in a tannery that does not properly manage its waste cannot be differentiated from a more responsibly tanned hide. In the future, buyers may be able to view the environmental credentials of the tannery even when the hide has been incorporated into a finished product. As supply chain traceability becomes more ubiquitous, market forces will likely bring about behavioral changes in business operations by rewarding good actors and removing market share from bad actors.
- SDG 12 - Responsible Production and Consumption. Supplies of rare woods are limited and it must be sustainably and transparently logged. The blockchain allows for trees to be uniquely identified and tracked throughout their life and post-logging. This ability to control the supply of lumber in order to ensure that it is legally produced will help to reduce the black market for illegally and unsustainably logged lumber. At present, buyers remain willfully, or innocently, unaware of their part in the illegal logging trade by relying on the word or certification of an intermediary who may be unethical. In the future, lumber will come with an authenticated passport, proving it is genuine and came from a sustainable source. Lumber without that certification will have a limited market and will find it harder to reach distant markets because shipping lines and customs departments will more easily be able to detect and impound illegal shipments.[5]

## II. Customs delays

13. Customs and Excise officials at any border are reliant on the information provided to them for making their decisions. The opportunity for unscrupulous actors to alter or fabricate information adds risk and distrust into the process. This risk and distrust then become delays, costs and uncertainty for all supply chain participants, irrespective of whether they are good actors or bad.

14. Information captured by a well-designed blockchain could present a more complete and more reliable data set to customs officials. This would, theoretically, allow them to both process goods through ports faster and also recover revenues owed more efficiently – even automatically.

## III. Visibility

15. One of the greatest inefficiencies in many supply chains is the time and effort required to gather accurate information on the location, condition and estimated-time-of-arrival (ETA) of goods within the supply chain. Blockchains can allow real-time access to accurate information that, in turn, facilitates faster, and better decision-making by stakeholders all along the supply chain. Access to information can be controlled via user profiles that specify the access permissions for each participant in order to ensure that competitive information is not shared with the wrong stakeholders.

## IV. Incident management

16. When a supply chain breaks, it can often be very hard to recreate it in order to understand the root cause of issues. For example, a listeria outbreak in the UK may have been caused by contaminated vegetables from a foreign country. Rapidly identifying which

[5] http://www.foodsafetynews.com/2014/10/foodborne-illnesses-cost-usa-15-6-billion-annually/#.Wmeuua3MzEY (as of January 2019)

country and which farm is responsible is key to maximizing the effectiveness of responses. According to the United States Department of Agriculture (USDA), food borne illnesses cost the US economy close to 16 billion USD per year. Of course, globally this figure is even bigger. Being able to prevent and react smartly to these incidents has an enormous impact on the costs and efficiencies of businesses even outside of the supply chain.

17. Producers who receive returned parts because of defects could have a much more accurate and reliable source of data to use for identifying the root causes of quality issues. A well designed blockchain identification system could allow them to identify the sources of the raw materials used, as well as the operators, supervisors and managers on shift during production and any other information that may be helpful in pattern recognition and root cause identification. This useful information could also include the history of the item after it left the factory.

18. Transport authorities who need reliable access to plan for and react to incidents involving the transport of dangerous goods could benefit from clear and immediate data from appropriate blockchains.

### V. Dispute resolution

19. Similar to "Incident management" discussed above, disputes that arise for reasons of timing, quantity or quality could be simpler to resolve if reliable data on these questions (for example delivery time and date) was recorded on a blockchain. In theory, some disputes could also be avoided by using a suite of smart contracts that self-execute, based upon conditions that are previously agreed by all parties, thus reducing administrative overheads and legal bills. See "Smart Contracts" under "Implementation Challenges" below.

### VI. Information ends at POS

20. Under current supply chain arrangements, with the limited exception of warranty-related items, the supply chain ends at final consignee. Contact is lost with the product and important information on its usage is not captured. Using technologies such as quick reference codes (QR codes) and radio-frequency identification (RFID) together with blockchain technology, the use of items during their lifecycle could be monitored with the user/consumer being automatically provided, via a blockchain, with consumer benefits, product development, onsale/upsale and loyalty programs, none of which have been practical using current, pre-blockchain technology

## C. Key stakeholders in improving supply chain transparency

21. Key stakeholders in improving supply-chain transparency include:

- Governments agencies including customs and excise.
    - Governments can leverage blockchain technologies in ways that will help them to streamline and improve the areas mentioned below. It will also make it easier for countries whose border systems are currently not as advanced as other countries to implement best-practices more cost-effectively:
        - Revenue taxation – blockchain data can make auditing companies far simpler and more accurate while speeding up the collection of owed taxes by automating the levying of charges;
        - Customs and excise – cross-border supply chains that leverage blockchain technology will allow customs officials

to increase their trust in the contents of shipment, allowing them to approve greater volumes of freight faster with less risk to the country's security and/or revenue; and

- Enforcement of compliance – easily being able to verify the contents of shipments/consignments and the sources of raw materials/finished products helps governmental bodies efficiently and effectively enforce their laws.

▪ Consumers

- Using near-field RFID technology and/or QR codes, blockchains will make it possible for consumers to quickly achieve high degrees of reliability in the provenance and transit conditions of any item that they are considering purchasing. By scanning the code using an appropriate app, it will be possible to visually display the entire history of the item, showing place and time of production and the transit/ storage conditions of the item up to that moment.

▪ Brokers

- Much has been made of the potential for blockchains to eliminate middlemen from supply chains. Brokers and middlemen may have their roles significantly changed by blockchains.

▪ Merchants

- Merchants will be able to manage their supply chains with greater accuracy, and lower friction.
- Merchants will be able to view their entire supply chain from any connected device, enabling better decision making, reducing waste and lowering costs.
- Falling costs of sensors, Internet-of-Things (IoT) devices and other technologies will allow merchants to cost-effectively protect themselves against counterfeit goods even before full end-to-end blockchains are implemented. For example: DNA tests can now be processed for under 100 USD. Random samples of meat that are supposedly from a specific herd/strain can be DNA tested and compared to DNA samples which that farmer has previously posted on the blockchain. This way it will be possible to tell quickly whether the received meat is coming from the expected herd regardless of whether the supply chain between the two parties is fully blockchain-enabled. This protects both the consumer and farmer from mid-chain substitution of high value meats and produce.

▪ Suppliers (primary and tertiary)

- By being part of a blockchain-linked supply chain, suppliers can add value to their businesses by reducing costs (automated data transfer, transparency of information) and potentially increasing margins and markets.
- Suppliers can get better quality feedback from stakeholders and consumers about their product. Consumers can be incentivized to deliver private feedback that suppliers can use to improve products. By limiting reviews to only those given by confirmed buyers it will be possible to increase the reliability of the feedback and reduce malicious or time-wasting reviews.

- According to the WTO, this has the potential to lower costs in trade, including for lower- and middle-income countries, making them more competitive and opening up new markets.[6]

▪ Freight forwarders & wholesalers

- By being able to accurately assess where shrinkage, damage and other events occur, freight forwarders can be held appropriately accountable only for value-deleting events that occur during their stewardship of the goods.
- Increased transparency and more consistent processing speeds for regulatory and administrative processes should facilitate more accurate planning, reduce downtime/waiting time, reduce demurrage costs and allow for greater efficiency in the deployment of equipment, manpower and space.

▪ Insurance stakeholders

- In some instances, it may be possible to offer more cost-effective insurance via the use of smart contracts, when it is possible to provide a blockchain with reliable data regarding insurable events. For example, when the temperature of a container with insured, temperature-sensitive, goods can be shown, via sensor data, to have been outside of the acceptable range for a determined time period, the smart contract could automatically pay the owner of the goods.

▪ Finance stakeholders

- Smart contracts may allow financial institutions to reduce risks by, for example, being able to provide loans to exporters based on invoices for export sales that have been verified by the importer on a blockchain.
- Using transactions and smart contracts on blockchains should support reduced costs, for example by allowing the automatic reconciliation of purchases, shipments and payments as well as smart contracts that trigger payments when reliable data on completed transactions is received (for example for a letter of credit)

## D. Implementation challenges

### I. Alignment of stakeholder interests

22. The strength of a chain is determined by its weakest link. So, it is that the strength (and therefore the value) of a blockchain is determined by the data registered on the blockchain in which users have the lowest level of confidence, just like the strength of a chain is determined by its weakest link.

23. There are many reasons to doubt the veracity of information captured in a blockchain where the party entering it has reason to enter inaccurate or fraudulent data. Consider a farmer who has been selling four times more volume of an organic crop than his farm can actually produce. Under the current process he may be able to purchase produce from uncertified farms in order to resell it at the premium he has negotiated with a client. In 2017 buyers only had that farmer's word for it, albeit backed by certification or independent audits, the reliability of which has been questioned by some. At present, cross-referencing that farm's total output to all customers is not a cost-effective proposition for any individual customer. Using blockchain technology, within a few years it will be possible for a farm or production facility's total shipped output across all of their customers to be readily visible to approved

[6] https://www.wto.org/english/res_e/booksp_e/blockchainrev18_e.pdf (as of January 2019)

users and quickly cross-referenced with the production capacity of the accredited unit. Any supplier, therefore, who sells more than they can physically produce will risk being exposed.

24. Suppliers who are currently playing a fair game will likely show significantly less resistance leaving implementation costs aside for a moment – see Costs below – to this full transparency. Those who have been profiting unethically in the past may be harder to align with the new supply chain requirements.

25. Banks are major players in supply chains and will need to be brought along to ensure that they can continue to support their client businesses. Fortunately, banks are among the earliest adopters and most aggressive investigators of blockchains for international trade and payment management. Some crypto-currencies have been designed specifically for this purpose.

## II. Standards

26. Blockchain has ignited the imagination of thousands of people for whom it offers the potential to solve many problems. Many businesses are actively pursuing pilots and proofs of concept (POCs) for applications that would allow them to reap the benefits from "lowest hanging fruit" solutions.

27. But what happens when the POCs meet in the real world? How will the projects talk to one another to transfer their data? Without adherence to standards such as those suggested in this paper, each blockchain will thrive in isolation but will run the risk of meeting with frustration, confusion and a large erosion of the deliverable value should it need to interact with external agencies and/or other blockchains.

28. Entities seeking to implement blockchain applications should therefore plan to exist in a broader blockchain ecosystem regardless of whether or not the initial implementation can be fully coded as only an in-house application.

29. A key term in supply chain management is the fluidity of information. This refers to the ability of data to flow quickly between parties without alteration.

30. Traditionally this has been achieved in two ways: by reducing the number of parties involved in order to reduce the number of data transfers required; and by adhering to standard protocols and data formats. The successful adoption of robust blockchain standards could have the effect of making the number of parties involved irrelevant because the opportunity to corrupt it would be reduced to zero.

## III. Data integrity from source – e.g. traceability

31. Similar to the alignment issues noted above and the cost issues mentioned below, the trustworthiness in the information carried by a blockchain depends on verified inputs occurring as early in the chain as possible.

32. In supply chains where value is added through aggregated production processes such as furniture manufacture, food & beverage production, etc. each raw input would ideally be captured on the blockchain prior to its arrival at the production facility. Failure to do so will limit the verifiable claims that manufacturers can make regarding the finished product. We can, therefore, expect that consumer demands/expectations will evolve and drive the need for accurate data inputs as far up the supply chain as possible.

## IV. Data collection

33. Data collection will need to be automated in order to maximize the efficiencies that can be achieved. Although the technology to achieve this already exists today (RFID, QR Codes and respective scanners as well as IoT sensors), there have been implementation challenges with accurate or incomplete readings when they are deployed at scale. These

issues will have to be addressed to ensure 100% accuracy at each stage to support the full reliance on the data that the blockchain collects. Any discrepancies in accuracy will undermine the usefulness of the system and therefore the adoption of blockchain technology.

## V. Anomaly management

34. The strength of a blockchain is its un-changeability. A weakness of a blockchains can be its un-changeability. What happens if data is inadvertently entered incorrectly (e.g. a sensor malfunctions)? How can users discern an amended entry[7] with positive intentions from one with malevolent intentions?

35. The ability of the network to recognize nodes with the authority to make correcting entries to original data will be critical to prevent hacking.

## VI.. Regulation

36. One of the headline features of blockchains is the potential for anonymity that they offer. Although anonymity is something that can be engineered into or out of any specific blockchain, the potential for hiding or obfuscating important information is of concern to governments. Without regulation it is possible for entire economies to operate out of sight, thereby avoiding taxes, fees and financial laws such as those on money-laundering. For example, using crypto-currencies to transfer value across-borders would allow for cross-border shipment of goods at lower values attracting lower taxes or tariffs with a secondary payment being made via anonymous crypto-currency to compensate the seller for the true value of the shipment.

37. Because of these concerns, governments are likely to be slower to embrace blockchains until clear and enforceable regulations are in place. Given the historic pace of change within most government organizations regulations are unlikely to keep pace with the speed of adoption desired by commercial entities.

38. What is likely to happen, therefore, is that businesses will seek forgiveness rather than permission and that the governments will have to work with what has already been implemented or risk the ire of business by making their requirements clear only after investments have been made.

39. In order to minimize such frictions, governments will need to be actively engaged in the development of open and international standards. In that way, businesses and governments can evolve in their understanding of the processes and risks at the same time.

40. Governments that lag behind and create or maintain barriers to the use of technologies, such as blockchain, that can improve the efficiency and effectiveness of business and government processes risk losing the competitive advantage of their national businesses and eventually the revenue that flows from these businesses. To that end, good businesses and good governments are entirely aligned on the motives for the adoption of blockchain and should be able to work out their differences when it comes to their competing agendas.

41. That said, businesses can anticipate many of the likely needs of governments and can work towards meeting those without external prompting. Most of the future regulatory requirements will mimic existing requirements and can be engineered to be met with relative simplicity and cost-effectiveness.

[7] The original entry is not changed, it is corrected/amended via a new entry according to rules set out in a smart contract.

## VII. Costs

42. For some stakeholders the benefits of blockchain may be indirect at best. In theory, and in aggregate, the total volume of trade may increase[8] based on increased trust and falling costs due to blockchain-related efficiencies. However, as a result of the transparency afforded by blockchains, those businesses that are currently – maybe unwittingly – engaged in the transport of counterfeit goods, conflict minerals or goods produced using forced or child labor may see their volumes fall off. In addition, small and medium-sized enterprises, especially in developing countries, may also be reluctant, or unable, to make the investments needed for participating in trade-related blockchain networks. Therefore, keeping the cost of implementation low is critical to removing the most obvious barriers to implementation by reluctant or doubtful parties.

43. The cost of sensors and computing power is falling to the point where installing the required hardware is unlikely to be a barrier to implementation in most regions. What is more likely to offer a legitimate implementation challenge is the provision of reliable, secure Internet connections at all of the required points. What may prove to be equally difficult is the provision of local technological support to maintain it. In some regions, the security required to protect hardware from damage or theft may also disproportionately increase the real costs.

44. A combination of wifi, mesh[9], broadband, cellular and satellite communications offers a solution to the communication needs of almost any location on earth. However, the installation and running costs of such solutions in remote areas may not be justifiable under a standard business case. In these instances, local, national, and even multi-national government agency support may be required in order to prevent suppliers from being forced out of or denied entry to markets by their inability to contribute essential information to the relevant blockchains.

## VIII. Securing the blockchain

45. The security of blockchains is typically achieved by having the risks associated with a malicious act far outweigh any likely benefit from successfully executing the act. Specifically, they seek to make the costs associated with being caught very large and the likelihood of success very low.

46. In order to achieve this, Bitcoin has become infamous for the amount of energy that it requires to secure and process its transactions. Similar proof-of-work protocols are unlikely to find favor in supply chain blockchain implementations. The environmental and economic costs are simply too high.

47. Other protocols such as Proof-of-Stake (POS)[10] are more appropriate in the blockchains envisaged for most supply chain applications. Private and semi-private blockchains are formed by groups of businesses, each of whom has a legitimate interest in protecting the validity of the data being handled. POS protocols allow honest actors to keep attackers at bay by making an attack economically unviable at a very low cost to the honest actors.

48. Blockchain designers will also have to consider the trade-offs between speed and security required for their blockchains. Individual supply chains will likely move slowly enough to accommodate the long latency (processing delays) that can accompany the highest levels of security protocols. Aggregations of chains into a holistic system for an entire

[8] For estimates of the World Economic Forum, see https://www.weforum.org/agenda/2018/09/blockchain-set-to-increase-global-trade-by-1-trillion/ (as of January 2019)

[9] https://computer.howstuffworks.com/how-wireless-mesh-networks-work.htm (as of January 2019)

[10] https://www.ethnews.com/proof-of-work-vs-proof-of-stake-explained (as of January 2019)

business or group of businesses will potentially introduce a transaction frequency that demands further examination. Designers will need to take into account the maximum latency that the system can handle and engineer in ways to meet a changing – most likely reducing – tolerance for delays in the future.

49. It is also important that blockchain designers create future-proofed security solutions for their systems in order to avoid forks[11] and updates to systems that fundamentally change stakeholder experiences once they have been enrolled in the process.

## IX. Privacy and liability

50. Strong permission-based access protocols offer a theoretical level of privacy that should meet the most exacting standards of business and governmental agencies. Any user's access to information within a private blockchain can be restricted by their permissions. However, as anyone who has worked within a large organization will attest, changing the permissions for access to even privately-held data is not an instantaneous or friction-less process. In order to verify approvals and action changes, several levels of approval may be required, and resources have to be made available, and paid for by someone.

51. Extrapolate these checks and balances across a supply chain that covers multiple users in multiple organizations, across multiple time zones, speaking multiple languages and you could have an access-to-information nightmare.

52. While predictable changes in user permissions could possibly be addressed by smart contracts, the infinite variety of requests that may be created by any blockchain that deals with a large number of users will inevitably lead to the necessity of human interventions.

53. Even when the process for giving and restricting access to information is solved to the satisfaction of all participants, the issue of liability remains. To whom are appeals made when confidential information is stolen by a malicious actor or shared with an unauthorized user? Who actually owns the data? These are complicated questions that will need to be answered, possibly in law, before blockchains can capture all the information necessary to unveil the full power of the technology.

## X. Smart contract coding

54. In order to maximize the efficiencies that could be created throughout a supply chain, it will likely be necessary to deploy smart contracts that automate transfers of ownership, the payment of funds and apply rules to transactions such as the registration of data on the blockchain (for example, a smart contract can enforce rules which only allow certain data, such as certificates, to be written to the blockchain by parties with a specific permission level).

55. There are two main challenges with smart contracts:

- First, smart contracts are still in their infancy and getting accurately coded contracts that mimic real life expectations may be time consuming and even require the reengineering of some processes and the resetting of expectations. It is also important to have smart contracts audited for security flaws as these can provide opportunities for hackers.

[11] A fork can occur when there is a major update to a blockchain, and one group of participants does not agree with the changes so they continue with the original governance and rules while another group accepts the changes in the update. The result is two blockchains that fork out from the original at the time of the implementation of the update. As a result, the history of data recorded on each fork is identical until date X (when the fork occurs) and then, after that time, the data registered on each fork is different.

- Second, smart contracts for funds transfers require that money is effectively placed in escrow until the smart contract terms are met. Even if operating in a fiat currency (called stable coins), this would likely create significant cashflow issues for some businesses that might not be offset by faster payments by their creditors. Cashflow challenges can be further complicated by the fluctuation of cryptocurrencies during the holding period, unless cryptocurrencies which are pegged to fiat currencies are used or the values of cryptocurrencies stabilize.

56. These challenges are not within the control of any supply chain and may need to be solved at a macro level before many parties are persuaded to fully embrace blockchains.

## E. Conclusions

57. We are at the very early stages in an evolution of business practices, and possibly even cultural consciousness, as consumers increasingly see, on a day-to-day basis, the impact of their choices on others and on their environment.

58. Those companies who lead the way in supply chain transparency will not be implementing fully functioning processes right out of the gate. Pareto's Law will be in evidence during the period from 2018 to 2022. That is to say, 80 percent of the value can likely be achieved with 20 percent of the final solution or 80 percent of the issues that are faced by current supply chains, in so far as transparency and traceability is concerned, can be addressed by focusing on 20 percent of the supply chains.

59. Potential high profile examples where supply chain transparency is critical include:

- Customs & excise;
- Logging;
- Leather goods;
- Transport of dangerous goods;
- Fresh produce;
  - Food contamination incident management
  - Limited supply verification
  - True shelf life analysis
  - Reorder timeliness through supply chain visibility
- Trade in Endangered Species[12];
- Retail;
  - Counterfeit management (such as wine, luxury/fancy goods, clothing, food, medicine)
  - Shrinkage management (such as any items with a retail black market or the improvement of reordering cycles through supply chain visibility).

[12] These are identified and the rules for their trade defined in the Convention on International Trade in Endangered Species (CITES)

# Section III: Maritime trade

## A. Introduction

### I. The importance of maritime transport to global trade[1]

1. With over eighty per cent of global trade by volume, and more than seventy per cent of its value, being carried on board ships and handled by seaports worldwide, the importance of maritime transport for trade and development cannot be overemphasized. In 2017, world seaborne trade volumes expanded by four per cent, up from 2.6 percent expansion in 2016, slightly above the historical average annual growth of 3.5 percent over the past four decades. Total volumes reached 10.7 billion tons, reflecting the addition of over 411 million tons of cargo, about half of which was attributed to dry-bulk commodities. The rapid expansion of e-commerce, enabled by digitalization and the use of electronic platforms, is a contributing factore to the growth in seaborne trade. Projections for the medium term also point to continued expansion, with volumes growing at an estimated compound annual growth rate of 3.8 percent between 2018 and 2023. Cargo flows are set to expand across all segments, with containerized and major dry bulk commodities trades recording the fastest growth:

- Global containerized trade expanded, with volumes attaining an estimated 140 million 20-foot equivalent units (TEUs) (MDS Transmodal, 2017);
- In 2016, world demand for dry bulk commodities shipments grew to a total of 4.9 billion tons.

2. In 2017 the number of thousands of dead weight tons of containers ships increased by 1,270 and oil tankers by 29,119. Overall, there was more than a three percent increase in the world fleet. The average time in port worldwide is estimated at 1.37 days or 33 hours. Container ships boast the best performance – less than 24 hours spent within port limits. In contrast, tankers and bulk carriers seem to have longer port stays.[2]

3. Despite modest improvement in world seaborne trade volumes in 2016, weaker world economic growth and rising cost pressures continued to weigh on the performance of world seaports. While these trends affect all ports, container ports are affected the most. In addition, container ports have been affected by the deployment of ever larger ships, the cascading of vessels from main trade lanes to secondary routes, a growing concentration in liner shipping companies, a reshuffling of liner shipping alliances and growing cybersecurity threats.

### II. Players in the maritime trade industry

4. The number of parties that play a role in the maritime trade industry is large. On average, both in the country of origin and in the country of final destination, about 40 parties/companies play defined roles in the transport and logistics flow. For one roundtrip, on average, a cargo vessel will call in at 5 load and 5 discharge ports and a total of 1,000 active users will be involved in the total transport and cargo flows.

5. These parties can be split into:

- Those directing the transport and cargo processes (carriers, ships agents, forwarding agents, consignors/consignees /notify, terminal operators, warehouse storage keepers);
- Operational service providers (boatmen, pilots, tugboats, lashers);

[1] UNCTAD, Review of Maritime Transport 2017 and UNCTAD, Review of Maritime Transport 2018.
[2] Source: Marine Traffic, 2017.

- Operational suppliers (provision suppliers, bunkers, waste collectors, repairs);
- Hinterland transport operators (road, rail, barge);
- Government agencies (customs, veterinary, police, ministry of transport/health, environmental protection, port authorities, coastguard, emergency services);
- Inspection authorities (surveyors, pest control, phytosanitary); and
- Financial supporting services (banks, insurance companies).

6. All these parties play an important role in the supply chain. Without timely information they face issues in their planning which results in inefficiency and additional costs. Proper, correct information is important and, in ports where Port Community Systems are in use, is available for all concerned parties from a central point of contact. Some parties in the maritime trade industry act as intermediaries (ship agents, customs agent, etc.) and blockchain technology may affect the way they work, so it is important for them to identify this impact and possible new role(s) for themselves in the blockchain era.

## III. Existing digital solutions in maritime trade

7. Many describe maritime trade as a very bureaucratic environment that involves large volumes of paper work. It is, however, important to emphasize that, in a significant number of countries, the majority of processes are now carried out using existing digital solutions, some of these are described below.

8. Shipping portals[3] are electronic transaction platforms, which provide essential digital processes for booking, tracking and tracing and documentation, and which allow customers to communicate with carriers.

9. A Single Window is defined as a facility that allows parties involved in trade and transport to lodge standardized information and documents with a single entry point to fulfil all import, export and transit-related regulatory requirements. If information is electronic, then individual data elements should only be submitted once.[4]

10. The EU Reporting Formalities Directive (2010/65/EU) that aims to simplify, harmonize, and rationalize administrative procedures and reporting requirements for maritime carriers calling at EU ports required that by June 1, 2015, Member States implement measures to allow the electronic submission and reception of reporting formalities concerning vessels, their crew and cargo via a national single window. This directive is currently under revision and a new, replacement directive was being discussed at the end of 2018.

11. A Port Community System (PCS) usually defines itself as a neutral and open electronic platform enabling intelligent and secure exchange of information between public and private stakeholders in order to improve the competitive position of the sea and air ports' communities. It is usually associated with a single port, or multiple port environments within an economy. Some governments regard the PCS as a private entity while, at the same time, considering it to be critical public infrastructure.[5]

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[3] 2.IPCSA, The role of PCS in the development of the National Single Window, 2011

[4] See UNECE Recommendation 33, 2005: http://www.unece.org/fileadmin/DAM/cefact/recommendations/rec33/rec33_trd352e.pdf (as of January 2019).

[5] See UN/CEFACT "Technical Note on Terminology for Single Window and other electronic platforms", 2017, page 5: http://www.unece.org/fileadmin/DAM/cefact/cf_plenary/2017_Plenary/ECE_TRADE_C_CEFACT_2017_10E_TechnicalNoteSW.pdf (as of January 2019).

12. A good collaboration between all the parties involved is one of the success factors of a PCS. Distinctive for all PCSs is the link to customs and port authorities and other institutions such as veterinary offices or the coastguard.

13. For all parties involved, the core benefits include having a standardized communication platform that links operational, logistical and commercial processes which results in higher efficiency and speed for port processes, particularly through the automation and reduction of paperwork as well as improved punctuality, reliability and costs. By eliminating unnecessary paperwork which can considerably slow cargo handling, PCSs contribute to sustainable transport logistics and support the ambition of meeting global carbon reduction requirements. PCSs also perform as 'Gateways to a National Single Window' connecting specific business sector actors to the public sector.

14. Digital Bill of Lading providers accommodate the possibility of the digital transfer of titles, three platforms for the digital transfer of Bill of Lading have currently been approved by Protection and Indemnity Clubs.

15. Each of these platforms acts as an intermediary between various trading partners, with the intent of replacing paper title documents with electronic equivalents. Their scope extends to the financial institutions which finance the transactions in question. These solutions are capable of performing the three functions of a bill of lading namely as a receipt, as a document of title and as a contract of carriage which incorporates the Hague or Hague-Visby Rules.

## B. Blockchain opportunities for maritime trade

16. Applications of blockchain technology can provide the following main opportunities and benefits for maritime trade, including for the logistics activities prior to and after seaborne transportation. These opportunities and benefits can be grouped as follows.

### I. An improved means of sharing, distributing and verifying information

17. Currently in the maritime world, bilateral messaging is frequently used between a sender and a receiver, leaving out all the other parties engaged in a transaction. A receiver or a sender may also be a community system, relaying information between parties and sometimes even sharing with others. A trader in one part of the world, usually needs to know about and consult a large number of various systems in order to get the status of their traded goods that are on the other side of the world. To help with these challenges, traders can procure a service which gathers the required information on their behalf. In addition, at the moment when a shipper shares information with someone else, that information may already be outdated – or someone else may have better information from a better source.

18. Efforts to create systems which are a single source of truth, such as the third/fourth party logistics (3PL or 4PL) provided Supply Chain Management (SCM) systems, or carrier portals, are essentially gathering information, copying information from various sources and storing them in a centralized database. However, information is required from intermediary providers (such as carriers) and, by design, a central database can always be altered by someone with such privileges. In addition, the timeliness and authentication of the data provided depends upon the aforementioned intermediaries and their participation in the system.

19. A blockchain has the potential to increase transparency and availability of information for all participants. A valid transaction stored in a shared ledger will exist in everyone's copy of that ledger. Transactions are not sent to a receiver but saved to a ledger which is then sent to everyone on the network with its updates. It is, therefore, possible for everyone or everything (based on the Internet of Things - IoT) that produces events in a transport chain

to potentially share that information with the world. As one IoT example, the crane of a terminal can report the successful loading of a container onto a ship.

20. A party having an interest in a transaction, such as the seller, buyer or banks, can simply consult their own copy of a shared ledger to see what the current status is or verify information relating to a transaction. This, therefore, increases trustworthiness between the parties beyond the correctness of the documents.

21. It is up to the design of the blockchain ledger and the systems around it, to determine how access to this information is granted to parties that hold a copy of that ledger.

> *"According to most study participants, the key advantages of distributed ledgers in comparison to existing systems and database technologies seem to lie in their automated reconciliation mechanisms, their transparent nature, and their resilience. The first removes traditional reconciliation efforts required for 'siloed' databases, thereby significantly increasing processing speed and reducing costs throughout the entire operational process.*
>
> *The second enables traceability of anything represented on the ledger, preventing manipulation through the public auditability of the system. Finally, the third provides higher availability and reliability, as well as protection at the system level against some types of cyberattacks."*[6]

## II. More efficient transfer of digital assets

22. The internet as we know it was built around freely copying information from one place to another. This is inherently unsuited to the transfer of assets due to the risk of double spending (selling the same asset twice). The lack of efficient options to ensure the security of assets has hindered the exploration of such options. Prior to blockchain technology, the secure digitalization of assets required the use of third-party intermediaries to guarantee the uniqueness of digital assets and related transactions which added a cost to these transactions. In addition, the related, centralized databases and intermediaries created single points of failure which prevented the wide adoption of such options.

23. Blockchain does enable the efficient and immediate transfer of assets. The most obvious transfer of assets, in transport, is the document giving title to the goods, one of the functions of the negotiable Bill of Lading. A payment obligation or a letter of credit may be its counterpart.

24. In their current form, non-negotiable seaway bills of lading, which remove the need to send paper documents to the destination for exchange when the goods are picked-up, still retain one problem: the goods are in the seller's possession until released at the destination to the receiver. The party who contracted carriage remains in control of the goods until just before delivery, and he may change the delivery instructions – including the consignee – as permitted under the terms of the contract of carriage. This provides reduced security for both trading partners. A blockchain digital transfer of assets could provide the benefits of quick transfer, and security to both parties.

25. With the possibility of efficiently transferring assets, blockchain technology offers the maritime industry an opportunity to explore other options – everything can become an asset. A space reservation, an allocation agreement, the right to pick up or drop-off a container at a terminal, time-slots in terminals, etc.

26. For example:

[6] 5.Dr Garrick Hileman & Michel Rauchs, Cambridge, "Global Blockchain Benchmarking Study," 2017 https://www.jbs.cam.ac.uk/fileadmin/user_upload/research/centres/alternative-finance/downloads/2017-09-27-ccaf-globalbchain.pdf

- A carrier may provide a cargo receiver with a "right to pick up the cargo" token. This token can be transferred to a trucker.
- A trucker may get a token from a terminal for a specific time-slot. If the trucker cannot keep his timeslot, he may pass it on to someone else. Or procure a time-slot himself.
- A carrier may issue securities for space on a voyage. That security may be traded or exchanged among different parties. Currently, this would require cancellations and rebookings and is tied to various sub-processes and actions required by multiple parties, making the process very inefficient. Intermediaries, such as freight forwarders have taken on this task in the past, with the recurring issue, that space ended up not being used, even during peak-seasons.
- Blockchain also provides the opportunity to separate the function of "document of title" from the "contract of carriage".

## III. Automation of contractual obligations through smart contracts

27. Current process automation stops at the point, where assets and their legal ownership must be exchanged. The exchange of goods against payment process is handled through different financial and physical flows. These two flows can be synchronized if both assets exist in (or can be represented by) a digital form. Swapping of assets can happen through smart contracts. For example, a negotiable Bill of Lading may be swapped against the payment obligation of the party financing the trade.

28. Common carriers may execute their right to a lien by swapping a negotiable Bill of Lading against payment of charges, at origin as well as at destination.

## IV. Increased security

*a. Document security related to negotiable Bills of Lading*

29. Paper documents today are exposed to various security threats. A negotiable Bill of Lading may be issued by one party only, therefore the information it contains may not be counter checked by other parties. Common fraudulent behaviors are the issuing of fake bills of lading, falsely dated bills of lading or documents containing false information created by switched bills of lading or false descriptions regarding the nature of goods. Bills of lading are also lost occasionally and then access to goods are usually only granted against bank guarantees exceeding the value of the cargo. While a digital asset can be lost as well, it is up to the party to ensure that their assets are stored and backed-up in a safe way (i.e. they do not have to rely upon a third party).

30. Blockchain applications mitigate such threats by using multiple sources to validate information. Issuers of documents and contributors of data elements may be identified with keys that prove their existence. The content of a document may be used to calculate a hash value, and that hash can be stored in a blockchain providing an immutable verification of the content. The content can be checked against that hash to verify if it is the original.

31. External sources can be used to add additional information and trigger transactions. These oracles may be a port, that verifies a vessel has departed, a terminal that has loaded the cargo onto the ship or even both. It will be possible to have the information verified by multiple parties which will make forgery much more complex to achieve.

32. Current applications to address these problems require third party, neutral, notarization services, that add transactional costs which many blockchain applications could eliminate.

33. In the case of a loss of a negotiable Bill of Lading, blockchain technology allows a carrier to track if an asset (the tokenized bill of lading) was indeed transferred to someone else. This is impossible to track and verify in a paper scenario. Carriers require bank guarantees provided by a seller/consignor or buyer/consignee to release the goods nevertheless. These guarantees often were set at 200% of the cargo value over a timespan of multiple years. With the data exchange traceability provided by blockchains, carriers may be able to very significantly reduce their risk of release without the presentation of the digital asset.

34. The above observations extend to other documents used in maritime transportation, such as certificates of origin, packing lists, dangerous goods declarations, customs bond documents, phytosanitary certificates etc.

*b. Right to access the goods*

35. There are ports where the current release information for goods is sent to cargo receivers through unencrypted e-mail. When pin-codes and container numbers are used to pick-up containers, it is still possible that this information is relayed to a wrong party: a party not authorized by the cargo owner to pick up the container. The same applies for the pick-up of an empty container or the drop-off of a full container at a terminal where, currently, unencrypted information is transferred by e-mail or paper. If such rights are tokenized and exchanged on a blockchain, then they exist only once and the use and transfer of these tokens can be traced.

*c. Trade compliance*

36. Regulations and compliance rules are generally enforced by human controls. With additional regulations being implemented worldwide, keeping up to date has become difficult. The increased number of transactions also leads to cognitive fatigue by the users verifying transactions. The review of paper documents by people also tends to be less predictable than the review of digitalized documents by information systems.

37. Through smart contracts, trade information may be shared with an algorithmic compliance checking system. Such systems can be continuously updated with the most current rules and regulations. In such a scenario, information for a transaction may be accessed by regulators that have access to a ledger, before the transaction happens.

38. If the compliance check results in approval, the transaction may proceed. In this case, the advantages of blockchain over a centralized database system are the ability to ensure that digitalized documents are originals (and cannot later be changed), reduced risks of fraud, and the ability for companies and regulators or third parties to provide this information without needing access to multiple company or regulatory systems.

39. A related application could be compliance checks against IMO rules for the transportation of dangerous goods by sea. It might even be useful, where regulatory verification services exist, to extend the scope of checks, that would allow stakeholders to check not only the IMO rules before the goods are transported, but also specific rules that may apply during the pre- or on-carriage of a containerized transport movement under different rules and regulations (i.e. special rules for inland water ways, country specific laws).

40. Distributed ledger networks provide regulators with the opportunity to monitor, supervise and audit trades and agreements in real time, which would be a drastic improvement over regulatory systems in place today.

*d. Terms and conditions*

41. The contract of carriage and its terms and conditions may not be clear to the party receiving the goods. Destination as well as auxiliary charges may apply such as destination

terminal handling, demurrage, detention or port storage. With the digitization of the release of goods, applications could require that terms be explicitly accepted by cargo receivers in an efficient way. Currently, these terms are not clearly visible to the receiving party as such terms are not visible on the contract of carriage itself. Such an application would provide transparency to the receiving party regarding the charges to be paid when requesting the pick up of goods, and it would assure the carrier that these charges are accepted by the receiving party.

*e. Time and cost reductions*

42. The main time and cost reductions can be achieved where paper is currently the only means to transfer information and title from one party to another because of the need to ensure that documents are unique or unchanged. Wherever there is currently a lot of such paperwork and many different stakeholders involved, efficiency gains can be achieved. In maritime, this is mainly the case where an original negotiable Bill of Lading is used. These paper documents travel normally by courier or mail from the issuing office to the shipper, his bank, the buyer's bank, the buyer and finally to the party releasing the goods.

43. Each of these paper-based transfers takes time to open, verify, and send to the next party. Depending on the distance between the parties, this process can take multiple days if not weeks and multiple courier or postage charges are applied. Undertaking these transfers using blockchain applications could result in funds being released faster to the seller, and buyers having options for refinancing goods that are in their legal possession, instead of funds being blocked by guarantees.

44. By using a secure and reliable digital document, each transfer can be done within minutes and is potentially cheaper than paying a courier or postal service. Compliance checks done by algorithms may verify information instantaneously. Then, if a regulator has the power to veto a transaction, can be done in real time. Through such immediate rejection, the regulator can prevent a vetoed transaction from being finalized. This can result in major time and cost saving as compared to correcting after a vetoed transaction has happened.

45. Registering and tracking information in one blockchain source, creates a chain of visibility allowing parties to quickly get information that, before, was locked in different information silos. Time intense and error-prone human reconciliation of transactions can be eliminated or reduced using blockchain applications and the laborious collection of information from multiple sources can become obsolete, thus reducing manual labor and costs. This approach also has the potential to reduce costs by allowing stakeholders to reduce the number of bilateral digital and paper interfaces they need to maintain.

## C. Challenges to implementing blockchain in maritime trade

46. While there are many potential benefits to implementing blockchain technology in maritime trade, there are also a number of important challenges to its implementation.

### I. Technology maturity

47. Even though blockchain technology has been around since 2009, and some of its components have even been used before, the technology is still not mature enough to be used widely in a conservative industry like the maritime trade. There are some more advanced blockchain platforms but it is still not clear which platform will last and a wrong decision today may lead to a lost investment so many of the maritime trading partners prefer to wait for a clearer picture.

## II. Lack of expert developers

48. Maritime trading partners that decide to implement blockchain technology today will find it difficult to access the needed expertise for implementing because there is a lack of blockchain talent and educational programs to develop such talent. There are a growing number of blockchain startups, including in the maritime trade sector but they primarily sell standard products/solutions and do not develop tailor-made applications

## III. Long transaction confirmation time

49. Many blockchains have transaction confirmation times that are too long for high-volume and time-sensitive transactions. Transaction confirmation times are determined by a range of parameters including the consensus mechanism used, the number of validators, the technology used, etc. Some blockchains have shorter confirmation times, although faster response time is often purchased at a cost which compromises, to some degree, other desirable blockchain characteristics.

50. In some maritime trade applications such delays would cause a serious problem, especially in applications that use real-time IoT devices for monitoring (for example of location, temperature, etc.) where transactions need to be confirmed and validated in a short time window, preferably milliseconds, and where the volume could reach millions per day. This is a key unresolved issue for the maritime sector and the results of current intense research by blockchain experts and organizations to resolve this issue, if successful, could unleash a tidal wave of applications that will transform trade.

## IV. Legal recognition

51. When looking to transform a maritime trade business process through the use of blockchain technology, one common concern is the recognition of the new process and its results by legal authorities, for example, in the case of a dispute.

52. It is, therefore, very important that blockchain technology be accepted by legal parties and, after thorough analyses, be accepted as a 100 % guarantee of the endorsement and reliability of the data.

53. In 2017, the United Nations Commission on International Trade Law (UNCITRAL) published the "Model Law on Electronic Transferable Records" which considers the possibility of using distributed ledger technologies. For example, one relevant paragraph is:

> *" 78. Certain electronic transferable records management systems, such as those based on distributed ledgers, may identify the signatory by referring to pseudonyms rather than to real names. That identification, and the possibility of linking pseudonym and real name, including based on factual elements to be found outside distributed ledger systems, could satisfy the requirement to identify the signatory."*[7]

54. This is an important development, at the same time, it will take time for countries to adopt the model law so that it is reflected in national legislation.

## V. Regulatory recognition

55. Some of the maritime trade processes are regulated by different authorities: port authority, customs, etc. and some of them also involve financial partners like banks and insurance companies that are also regulated by other authorities.

56. Some of those authorities, like the International Plant Protection Convention (IPPC) are just recently making efforts to move away from paper documents. In the case of the IPPC, the phytosanitary certificate is being moved to a digital e-phyto certificate based on

[7] UNCITRAL, Model Law on Electronic Transferable Record, 2017

UN/CEFACT XML files and it may be a challenge to then move this solution to a blockchain-based solution.

## VI. Data ownership, personal privacy, General Data Protection Regulation

57. Maritime trade community members are sometimes competitors and sometimes may be partners and if they are using one blockchain network, special care will need to be taken to protect the data and to give blockchain network members access only to relevant information. In addition, the protection of private information needs to be considered, including user names, contact details and information where users can be identified such as data for the shipment of personal goods. Under the new European Union General Data Protection Regulation (EU GDPR) which came into force in 2018 there is a requirement to protect privacy by design, i.e. it should be part of the design and development of the system. In addition, the law also provides for the right to be forgotten and if one party/individual in a blockchain requests to be forgotten there are still questions over how, in a blockchain or archived blockchain, this can be achieved.

## VII. Overlap between solutions

58. The maritime trade sector is not an isolated island in the supply chain. Many aspects of maritime trade influence and are influenced by other sectors: finance, insurance, land transportation (trucks/rail), agriculture, etc.

59. There are blockchain initiatives in all of those sectors that compete for the resources of their partners and the lack of coordination between relevant initiatives slows down the progress of all the initiatives.

## VIII. Interoperability of blockchain networks

60. Even though there are blockchain initiatives in the maritime trade sector that aim to provide solutions to all maritime trade members and to all of their needs, we believe that, in the end, there will be a number of co-existing solutions.

61. If those networks won't intercommunicate with each other, they will be silos of information, not allowing users to see the whole supply chain picture and will reduce the overall effectiveness of each blockchain network.

## IX. Use blockchain only when needed

62. “Through 2018, 85% of blockchain-named projects would deliver business value without using a blockchain.”[8] Maritime-trade participants should study carefully the business processes they want to implement with blockchain technology and do so only for those that can't be done better using other technologies.

## X. Multiple players with different technology adoption levels

63. The maritime trade community has a huge number of stakeholders as detailed above, and a significant percentage are conservative companies or small/medium companies that will not adopt quickly new technology.

64. To allow the early adopters in the maritime trade sector to use blockchain technology, while still doing business with the late adopters, there is a need for parties that will supply mediating procedures or bridge technologies that will allow this to happen.

65. UNCITRAL in the “Model Law on Electronic Transferable Records” also mentions the need to handle this situation from the legal perspective:

[8] 4.Rajesh Kandaswamy, Gartner webinar, 2017

*"161. If the law recognizes the use of both transferable documents or instruments and electronic transferable records, the need for a change of medium may arise during the life cycle of those documents, instruments or records. Enabling change of medium is critical for the wider acceptance and use of electronic transferable records, especially when used across borders, given the different levels of acceptance of electronic means and readiness for their use in different States and business communities."*[9]

### XI. Need to change business processes

66. The following quote from a Cambridge study is very relevant to the conservative maritime trade community: “Another major challenge to DLT that needs to be overcome is the general reluctance of enterprises to change established business processes, which is, in many cases, a necessary requirement for DLT to take meaningful effect.”[10]

### XII. Missing open standards

67. Many blockchain startups are using proprietary standards with different data definitions for the same data element, thus causing potential confusion in the market place, particularly where data needs to be exchanged between multiple parties. Data Definitions and Data elements should comply with currently used international standards which in the maritime industry is UN/EDIFACT and thus, by default, with the Multi Modal Transport Reference Data Model which is based on a subset of the Core Component Library of UN/CEFACT.

### XIII. Cybersecurity threats and risks

68. Like most trade sectors, the maritime trade sector deals with growing cybersecurity threats. To adopt blockchain in the maritime trade, its members have to be confident that this technology is safe. The introduction of quantum computers in the future may affect blockchain security so the development and implementation of quantum proof blockchain may create more trustworthiness by maritime trade members in blockchain.

### XIV. MSMEs’ ability to be integrated into blockchain-based systems

69. Most Micro, Small and Medium sized Enterprises (MSMEs) that take part in maritime trade lack the technological expertise to implement blockchain solutions and thus will require support from third parties to implement a solution. This could lead to a two-speed technological change where large enterprises with the technological knowhow start to run blockchain solutions which affect MSME’s but these MSME’s require third party support and this could increase their costs when compared to current solutions.

## D. Existing case studies

70. As described in the Annexes (I-VII), the authors have identified a number of important use cases that can be divided to various types of solutions such as digitalize a specific paper-based business process that; improve business processes that are already digitalized; digitalize an entire section that is all paper/e-mail based; digital solution for a new need.

[9] UNCITRAL, Model Law on Electronic Transferable Record, 2017

[10] Dr Garrick Hileman & Michel Rauchs, Cambridge, “Global Blockchain Benchmarking Study,” 2017 https://www.jbs.cam.ac.uk/fileadmin/user_upload/research/centres/alternative-finance/downloads/2017-09-27-ccaf-globalbchain.pdf

71. No blockchain solutions with widespread implementation in the maritime trade sector were identified during the research for this chapter.

72. As blockchain applications come on line, the first initiatives have been based on existing processes where the business case is based on positive results from improved data maturity, reduced times for the implementation of contractual obligation and increased transparency in the supply chain. The next step will affect the position of the various players in the supply chain because present processes and especially those with a focus on checking the validity of documents/data may become obsolete, thus influencing the roles played by various stakeholders.

## E. Conclusions

73. More than 80 percent of global trade by volume is carried by the international shipping industry. Any increased efficiency in the maritime trade sector can have significant effects on global GDP. Blockchain may be one of the key drivers for enhancing the efficiency of maritime trade in the future.

74. As described above, blockchain can bring many opportunities and benefits to maritime trade:

- Better means of sharing/distributing/verifying information exchanges and for transferring digital assets;
- A driver for process automation.

75. This can lead to time and cost reductions, so it is important to keep investigating the opportunities and benefits that it can bring and implement wisely the identified blockchain-based solutions. Blockchain is not the solution for all problems so it is important to implement blockchain in maritime trade processes that take advantage of the special characteristics of the technology.

76. We expect that in the maritime trade sector and at its interfaces there will be a number of blockchain solutions, and for that reason working on interoperability standards between different blockchain networks is extremely important and UNCEFACT may have an important role to play in this area.

77. Open, international standards such as those produced by UN/CEFACT will be essential to ensuring the interoperability of blockchain solutions.

81. Port Community Systems, which are existing trusted networks for process harmonization and integration, could bring added value in the implementation of blockchain-based business processes in the maritime trade sector. As one example, Port Community Systems may be able to be the bridge between different blockchain local/global networks and the different technology adoption levels of users.

82. Is blockchain a game changer in maritime trade? We assume it is, the introduction of blockchain has acted as a wakeup call to this traditional and conservative community that is now very busy running a large number of blockchain proof of concept and trial implementation initiatives.

83. Important factors that could delay the impact of blockchain applications as a game changer in maritime trade is the access to know-how about maritime logistics and the lack of developers with blockchain expertise as described above.

# Section IV: Road Transport

## A. Introduction

1. Road transport is a crucial economic activity. It brings people together and it carries goods to where they are needed. As an illustration, 99 percent of the daily needs of the population is delivered by road.

2. Moreover, the provision of road transport services is an important economic sector in its own right. Within the European Union, it provides employment to three million people carrying freight and generates a turnover of 330 billion euros in freight transport. Total inland freight transport in the EU-28 was estimated to be just over 2 200 billion tonne-kilometres (tkm) in 2014; some three quarters of this freight total was transported over roads. The share of the 28 Member States of the European Union (EU-28) inland freight that was transported by road (74.9 percent) was more than four times as high as the share transported by rail (18.4 percent), while the remainder (6.7 percent) of the freight transported in the EU-28 in 2014 was carried along inland waterways. In 2016, 85.3 percent of EU-28 road transport was done by vehicles with a maximum permissible weight, when loaded, of over 30 tons. Vehicles with a maximum permissible loaded weight of under 10 tons represented 0.6 percent of the EU-28 transport performance. In 2014, there were around 550,000 companies in the EU providing road haulage services for hire and reward as their main business.[1]

3. In France for example, road transport represents more than 35000 companies with a turnover of more than 53 billion Euros. It is one of the ten largest French private employers with more than 400.000 employees.[2]

4. Customer expectations are increasing greatly. Both individuals and businesses expect to get goods faster, more flexibly, and – in the case of consumers – at low or no delivery cost. In addition, manufacturing is becoming more and more customized, which is good for customers but hard work for the logistics industry. Add it all together and the sector is under growing pressure to deliver better service at an ever lower cost.

5. An increasingly competitive environment is another big factor in the mix. Some of the sector's customers are starting up their own logistics operations, and new entrants to the industry are finding ways to carve out the more lucrative elements of the value chain by exploiting digital technology or new sharing business models, and they don't have asset-heavy balance sheets or cumbersome existing systems weighing them down.

6. Manufacturing industries are facing far greater expectations with regard to efficiency and performance than ever before. Their customers expect faster time-to-market, reduced defect rates and customized products.

7. As in other transport industries, the road transport industry uses a lot of paper, not to say that it uses exclusively paper. However, in the case of road transport, it's even worse than other transport sectors because of historical issues of equipment and Internet access on the road.

8. On top of the transport document itself, there are other documents which need to be handled by the carrier or carried on board the truck such as driver's card, mandatory training certification, agreement certificates, licenses, technical inspection certificate, invoices for the goods transported, consignment notes, documents for ports/docks, bills of lading, customs documents if needed, fiscal documents and many others.

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[1] Source European Union Directorate General of Transport: http://bit.ly/2BP61Ya (as of January 2019).

[2] Source FNTR: http://bit.ly/2lcIz0E (as of January 2019).

9. In addition, commercial shipping transactions also involve a large number of papers, such as sales contracts, charter party agreements, bills of lading, consignment notes, letters of credit and others, some of which overlap with those which the carrier and truck driver must manage. All these documents may need to pass through a long chain of parties with many controls since their importance is high, with various payments as well as the carriage and delivery of the cargo depending upon their existence and accuracy. Look for example at the bills of lading and the long trail they follow: starting from the party(s) at the loading port, they pass through several banks until they reach the receiver of the merchandise. This procedure can be so lengthy and time-consuming that it is very common for vessels to arrive at the discharge port before the bills of lading (and likewise for the arrival of trucks at destination before their related bills of lading).

10. Another factor to consider is that, today, road transport vehicles are highly connected with many electronic devices which provide information to drivers in real time (i.e., help for an economical driving, best routes, how to avoid traffic, toll payments, etc.). They are being equipped with devices that also collect an exponential quantity of quantitative data (i.e., driving and resting times, number of kilometers travelled, energy/fuel consumption, etc.), as well as qualitative data (i.e., styles of conduct, historical or real-time location, video sequences showing the road or the inside of the vehicle, etc.).

11. This data collected on-board, can be added to other data, which can be internal to the company (i.e., from purchasing departments, sales, maintenance, human resources etc.), as well as external data, mainly concerning the state of the road network like the traffic, the weather forecasts, the impact of big sports or cultural events on road congestion, etc.

12. If every time a product changed hands the transaction could be documented, creating a permanent history of a product and its journey from manufacture to sale, this could dramatically reduce the time delays, costs, and human error that plague transactions today.

13. Blockchain technology can support the development of such systems and has the potential to revolutionize the future of trucking and logistics by providing the basis for new systems for completing transactions, tracking shipments, managing fleets, solving claims and much more.

14. Blockchain-based applications can bring together, and record in a trustworthy manner, information that is currently on paper and information gathered by Internet of Things sensors. By providing trustworthy information on cargos, transport and related payments, blockchain could provide supply-chain participants with: efficiency gains; savings in terms of document management; better and quicker decision processes; quicker invoicing process; better controls from the authorities on the legal aspects of the transport; etc.

15. Business transactions surrounding the shipment of freight can be automated using blockchain-based smart contracts which improve upon traditional contracts by enforcing the rules controlling the transfer of currency or assets under specific conditions. In simplified terms, blockchain systems use a chain of cryptographically protected records to make available the details of transactions to all participants and distribute transaction records across the network of participating nodes, or computers, thereby eliminating the need for a central authority to maintain records, which makes processes more efficient and cuts costs.

16. Logistics solutions based on blockchain technology are being developed by start-ups and gaining momentum in areas such as digitalized trade documents, chain of custody, customs clearance, and trade finance.

17. Blockchain technology also fosters automation and efficiency through its trustworthy peer-to-peer network, thereby reducing delays, human error, and transaction costs for interactions between supply chain partners – for example, for the processing of international trade documents.

18. As a result, supply chains become more transparent, with blockchain-backed services offering an easy and trustworthy authentication of shipments.

19. Identified potential benefits:

- Accelerated payment, better security and reduction of fraud;
- Simplified claims settlement;
- Improved traceability and trackability;
- Elimination of middlemen, which cuts costs, reduces paperwork and shortens the supply chain;
- Reduction in the cost of complying with regulations; and
- Increased transparency in prices, ownership and the entire process.

20. Blockchain technology offers many different benefits to the transport and supply-chain sector, and its applications range from simple asset tracking and transparency to real-time feedback from customers. The scope of the benefits offered by blockchain technology is vast, and it could be one of the most remarkable breakthroughs in supply-chain history.

21. At the time of its inception, over two thousand years ago by Alexander the Great, the supply chain was a revolutionary idea designed to provide a military advantage to troops that were better supplied. This concept was then much further refined and developed in parallel with the development of assembly line manufacturing in order to improve the visibility and control of goods and products as they moved from point A to point B.

22. But the old concept and its related technologies can no longer support today's production and supply cycles, which have become extremely fragmented, complicated, hard to manage and geographically dispersed as well as being increasingly time sensitive due to the development of just-in-time manufacturing.

23. The business networks supporting supply chains include many participants, including customers, suppliers, banks, partners and others. Supply chains are also linked to communications, energy, transportation, finance, manufacturing… there's almost no limit.

24. Business networks, whether they involve buying something, getting goods shipped, manufacturing or maintaining assets, involve a network of participants cooperating with some shared objectives for agreed upon transfers and record keeping.

25. Goods, services and documents/information are exchanged daily on these networks, however, keeping track of these transactions is a complicated and paper-intensive process, in large part because businesses have multiple ledgers for the multiple networks in which they participate.

26. Historically, these records are on paper and are handled manual. Today, many of these records are electronic, however, they often rely on physical data entry by different parties and are located in different computer systems in different companies and departments. As a result, these records, still, often require time consuming and, sometimes, manual interventions to ensure that records are properly reconciled (for example to ensure that all goods ordered were shipped; all goods shipped were invoiced and all goods invoiced were paid, etc.).

27. The problem with paper records and dispersed, multi-party manual data entry is that the information becomes subject to a relatively high error rate. Therefore, the existing systems looks inefficient, expensive and vulnerable even though they have been in use for decades.

28. One potential future use of blockchain in transport is improved asset utilization through open forecasting. A 2016 report, "Trust in trade, toward stronger supply chains",

emphasizes the importance of trustworthiness and forecasting.[3] Carriers, for example, almost always receive orders only a few days in advance. This makes it difficult for them to optimize cargo or infrastructure and to aggregate the kinds of data they would need to forecast their transport capacity needs.

29. With access to better data, carriers could more accurately predict where capacity will be needed and more dynamically route their vehicles into these areas. This kind of cooperation could also reduce inventories and ensure that demand for capacity and, as a result, transportation charging rates, reflect actual needs and are not artificial numbers which fluctuate widely. A carrier might not have a trusted relationship with a consignor or manufacturer, but participating together in a blockchain network could change this. Transparency and visibility could open up new partnerships that they hadn't considered before. Drivers will have an important role in the blockchain, too, as they add their own data, often automatically, such as times on and off duty, the road conditions, condition of the load and vehicle and much more.

30. Information registered on the blockchain by remote sensors could also help carriers in disputes with consignors or their own sub-contractors about when and where an event, such as a crash or goods damage, occurred. It might also support their opinion about unsafe vehicles or those that require repairs.

31. More details about benefits that blockchain technology could bring to specific problems are described below.

## B. Theft prevention

32. Globally, cargo theft costs the road and rail transport industries between 23[4] and 60[5] billion USD per year.[6] Blockchain technology can help in discouraging and nearly eliminating some forms of cargo theft. One common form of theft is for a thief to identify a scheduled pickup time and show up two hours earlier using the excuse that traffic was light. A dock worker, none the wiser, looks at the paperwork and it all appears in order, so the trailer is loaded, or the driver hooks up to a loaded trailer, and no one suspects anything until the real carrier arrives a few hours later. By then, the thief and load are long gone.

33. Using blockchain technology, it becomes much more difficult for a thief to perform such a hold up. You can do a much better job identifying who is who because of the ability to easily connect to a blockchain where information, linked to the goods by a unique digital identifier, has been registered and cannot be hacked. This can provide the dockworker with a verified digital copy of the paperwork and even a photo showing who the driver is.

34. Carriers can also have a secure record of who accesses the system to obtain information using blockchain. These same blockchain characteristics (including the registration of data from remote sensors through the Internet of Things) can reduce theft by providing a continual, and transparent, record of a shipment's status. Digitally verified, information about how many boxes were loaded and unloaded on a trailer can be combined with GPS data and even door sensors that indicate when and where the trailer doors were opened. This data can then be used to quickly identify the exact point of a theft.

[3] See https://www-01.ibm.com/common/ssi/cgi-bin/ssialias?htmlfid=GBE03771USEN& (as of January 2019).

[4] https://www.securecargo.org/news/cargo-theft-and-supply-chain-disruption-cost-56bn-last-year-and-theres-more-to-come (as of January 2019)

[5] http://www.tlimagazine.com/sections/columns/1829-cargo-theft-today (as of January 2019)

[6] Also see https://www.ttclub.com/fileadmin/uploads/tt-club/Documents/BSI_TT_ClubCargoTheftReportH1_2018_FinalRev.pdf (as of January 2019)

35. In the case of cargo theft, who can you trust? A digital record can go a long way toward creating that trustworthiness. In addition to preventing the theft of trailers and cargo by creating easily identifiable indicators to verify legitimate carriers, blockchain also has the potential to prevent theft of even a single box from a trailer.

36. To address this issue, one approach is to use encrypted microchips to track goods and prevent counterfeiters.[7] For instance, a microchip can be attached to artwork, sneakers, wine or anything else that is frequently faked so that the buyer can verify the item's authenticity. The same technology could, potentially, be used in the supply chain by adding microchips or GPS trackers onto individual boxes, pallets or trailers. Data collected from these devices could be added to the blockchain all along the steps in the supply chain, using GPS data, ensuring that every box and pallet arrives at its destination in good shape.

37. The section on supply chains contains more information on the use of blockchain for tracking the provenance of goods.

## C. Fleet and asset management

38. Today's container-based logistics systems requires the management of very complex processes for matching goods with available containers and transporters, moving across multiple transport modes to a range of global destinations and very commonly using multiple logistics service providers for individual shipments, resulting in complex networks of partners and contracts. Just to give an idea of the volumes of data concerned, the numbers of containers shipped via maritime ports during 2018 was over 150 million[8] with 5 percent growth predicted for 2019.[9] The vast majority of these containers were brought to or picked up from ports via road transport (and some via combinations of road and rail). Many of these containers contain consignments from multiple consignors, going to different final destinations. These statistics do not include the many containers that stay on trucks and do not change transport modes, or which travel via only road and rail. In addition to managing these consignments in one direction, transport companies need to reduce costs and carbon emissions by keeping their trucks and containers filled on return trips.

39. Blockchain could support this planning. One example is in-vehicle tracking systems which could supply data to the blockchain allowing the verification of a truck's route, its speed, and any delays. This would provide verifiable documentation for fleets to justify delays, for example. Because each entry in a blockchain is also time-stamped, these entries could also be used to justify/explain detention billing.

40. Another approach being considered to these complex planning, billing and reconciliation processes is blockchain-based bidding processes for managing containers, trucks and other assets such as pallets.

41. For example, a company in Finland is working on a blockchain solution to enable smart tendering across supply chains in order to manage the use of pallets.[10] Pallets equipped with Radio Frequency Identification (RFID) tags publish their need to get from point A to point B on the ledger. Carrier applications then place bids to win the move. The blockchain awards the job to the bidder with the most suitable conditions and the transaction is registered on the blockchain. The shipment/pallet will be progressively tracked as the tag moves down

[7] https://chronicled.com/ (as of January 2019)

[8] UNCTAD Maritime Transport Report 2018, figure 1.5 - https://unctad.org/en/PublicationsLibrary/rmt2018_en.pdf (as of January 2019)

[9] https://www.mdst.co.uk/changing-lanes (as of January 2019)

[10] https://www.forbes.com/sites/stevebanker/2016/06/05/building-a-secure-transportation-tendering-and-tracking-application/#232f537a4e5c (as of January 2019)

the supply chain and pallets that are available for re-use can be identified and, possibly, recycled

42. Each of the trucks and railway cars involved in goods transport also needs to be properly maintained, so their mileage and repairs need to be tracked. One potential maintenance application could be management of information from Driver Vehicle Condition Report (DVCRs) that a driver fills out before and after the completion of a trip. Currently this is a very paper intensive process that should convey the condition of transportation equipment to operations, safety and maintenance. If automated and incorporated into a blockchain, all the inspection and maintenance information could travel with the equipment throughout its lifecycle, including through changes of ownership.

43. Verification of the inspections, maintenance performance records and recall information could all be part of this blockchain. This would ultimately simplify the asset management and utilization task.

44. Most truck Original Equipment Manufacturers (OEM) have introduced remote diagnostic capabilities where vehicles can send codes, back to the maintenance shop for diagnosing and repair. But what if that repair code is tied to a recall, can this be identified? Also, maybe only some trucks in a fleet are affected by a recall because the part has already been replaced on others. Using blockchain, identifying affected vehicles could take seconds because each repair for each vehicle would have already been entered into that vehicle's blockchain data. Blockchain could also be used to track the origin and maintenance of individual components of a vehicle.

45. Another example is on-road repairs which are a necessary evil, but fleets don't always have their own shop in locations where their vehicles are. In those situations, a blockchain application that tracks repairs and service providers could identify which repairs the local repair shop has performed, the quality of the work and whether the parts used have been genuine.

46. A blockchain could maintain a visible record to hold each person who performs maintenance on a vehicle responsible for their work. That kind of detail provides increased visibility into the supply chain, making everyone more confident in the movement of goods while increasing safety and on-time performance.

## D. Proof of regulatory compliance

47. Possibilities for benefiting from blockchain technology exist wherever there is not a trusted relationship between parties. In this respect, one area where blockchain technology could provide a major boost, is in proving regulatory compliance and chain of custody to enforcement authorities. For example, blockchain records could help guarantee precise and fair road checks by inspectors for cabotage (the regulated transport of goods or passengers between two places in the same country by a transport operator from another country).

48. The integrity of a document, such as a consignment note for road transport[11] (called a CMR[12]), could be issued, handled and exchanged on a blockchain in a digitalized way, and this would perfectly fit the authorities' requirement that the document provided to them be the sole and only version/copy, thus avoiding the current practice of multiple CMRs being

[11] The CMR is a document prepared by a consignor and countersigned by the carrier as a proof of receipt of a consignment for delivery at the destination. Used as an alternative to a bill of lading (especially in inland transport), it is generally neither a contract of carriage nor a negotiable instrument (i.e. it cannot be used for transferring the ownership of the goods).

[12] CMR stands for 'Convention relative au contrat de transport international de Marchandises par route,' the French name for the convention that governs its definitions and application

handled for the same load which makes efficient controls difficult to perform. It will also simplify the checks of consignment notes and make them quicker.

49. Another highly regulated sector, where the use of blockchain would make sense, is the transport of food products. The everchanging regulations for the transport of this kind of goods, have tightened the rules around the transportation of food products and have even gone so far, in some countries, as to stipulate when and how often trailers must be cleaned.

50. All this information, including the cleaning and maintenance of vehicles as well as temperature verification inside the trailer, can be digitalized and easily transferred to a blockchain for access, as needed, by authorities, transport companies and shippers. More on the use of blockchain in agricultural trade can be found in the section on agriculture.

## E. Additional benefits of blockchain technology for road transport

51. Some additional benefits of blockchain technology for road transport can be summarized into the following major categories, which complement the very specific benefits described above.

### I. Compliance and transparency

52. Transparency is the most influential and important benefit of blockchains. Blockchains will help to prevent organizational silos within supply chains and help supply chain leadership, better identify and understand how to make the supply chain more efficient and productive.

### II. Better tracking of orders and assets

53. Since blockchains, when combined with other technologies, can allow the trustworthy tracking of goods throughout their entire life-cycle and related processes, companies using blockchain technology will be able to more readily produce detailed information about a product, including supplier information, manufacturing details and logistics information. Examples of benefits to road transport include the ability to: identify quickly the party currently in possession of the goods; allocate costs to specific shipments; prove time and place of delivery; and undertake complex accounting, for example for determining carbon footprints.

### III. Reduction in errors in payment processing and auditing

54. Occasionally, auditing may not identify all potential over and under billings or payments. But, blockchain technology can help reducing these errors using smart contracts for reconciliation and by providing a trustworthy and defined information-trail. This can then support the quick identification of where a problem has occurred. As a result, the company concerned will be able to verify all operating systems that were affected by such errors and make changes to prevent the problem from occurring again.

### IV. Reductions in data-based fraud

55. Even the most detailed audits can overlook indicators of fraud hidden in thousands of pieces of data. However, blockchain technology is already enabling today's supply-chain entities to reduce and identify attempted fraud more easily.

56. For example, that the use of blockchain will deter attempts to change data because both the responsible party and the change to the data can be quickly identified on a blockchain, so no secret changes. Indeed, any attempt to change data which has been already registered on a blockchain will normally be rejected as part of the consensus process for adding new data. This would both prevent fraud from occurring and allow companies to

recognize the parties attempting to make unauthorized changes, driving down costs from potential fraud.

### V. Building trustworthiness

57. If a customer has trustworthy information about where a product originated, they are more likely to develop a longer-term relationship with a given supply-chain entity.

58. This extends beyond supplier information, blockchain-based applications could also collect trustworthy information about a company's services; for example, in the logistics industry, on-time delivery, percentages of lost or damaged cargo, quality of warehousing and other services.

### VI. Real-time feedback from consumers

59. The benefits of blockchain technology can also include trustworthy information on how customers respond to products and services. This information can be based on classic rating systems or analyses undertaken by artificial intelligence programs, where a blockchain could also record the algorithms used to come to the conclusions given.

60. In addition, this feedback can be connected to the information about suppliers and manufacturers, which can help supply chain participants create timelier and more accurate business forecasts.

### VII. Possibilities for increased cooperation

61. With trustworthy information registered on a blockchain, the various actors of the transport network could interact with each other in a transparent and real-time way. This could be based, at least in part, on smart contracts compliant with the needs of the sector and the regulations in force within the transport industry. The data shared as part of this cooperation, and registered on a blockchain, could be traced, secured and timestamped, without any intervention by a trusted third party thus helping to secure the integrity of the information shared. This supports new business models, based on cooperative competition, which can be advantageous to all when used to pursue common objectives and could support optimization in the transport sector in areas which are still to be discovered.

## F. Conclusion

62. As a distributed ledger that ensures both transparency and security, blockchain technology shows promise as a tool to address some of the current problems in road transport as a part of wider supply chains. With a world of transport that is becoming more connected every day, blockchain technology will, by nature, develop a symbiotic relationship with the Internet of Things and today's advanced logistics and supply-chain management systems.

# Section V: Agricultural, fisheries and food trade

## A. Introduction: the role of information in food integrity

1. In general, agricultural and fish products have 3 destinations:

- The first and most important destination is fresh food and processed food;
- Second, a substantial quantity serves as a commodity for industry, especially fiber and oil products;
- Third destination is as an input for agricultural and fish production, such as animal feed and soil fertility maintenance.

2. Information integrity is an important issue in agriculture, fisheries and food. This is because of the health implications related to food safety. Society requests and expects safe food and safe products. For agricultural and fish production the supply chain is very complex; it involves multinational companies as well as many small and medium processors and traders in addition to small farmers and fishermen. Sometimes, supply may be limited to a local production chain; but, on many occasions, it is a complex global production chain.

3. Food and animal feed are high-risk products; as such, the information about the product must maintain high standards of integrity. The level of product information integrity varies, depending on the person or organization involved, the activity performed, the processing of the product, the information about the product and the exchange of information between parties.

4. Food and feed safety is dependent on:

- Product characteristics;
- Animal and plant health (sanitary issues);
- Environmental conditions;
- Process and hygiene; and
- Inputs with reliable characteristics.

5. Food integrity is related to the following product attributes

- Substance;
- Origin/provenance;
- Quality; and
- Other characteristics.

6. The EU General Food Law and the World Health Organization's (WHO) Hazard Analysis and Critical Control Points (HACCP) guidelines are among the many legislative texts that provide for basic levels of food and feed safety. Regulations usually require that the food and feed producing parties have a legal identity and be registered and licensed. In most cases, farmers are not considered to be a food or feed producing party and as a result, are not required to be registered. However, due to programs to assist farmers, most farmers are registered.

7. In the case of electronic information exchange, parties must also have an electronic identity.

8. Because livestock is particularly vulnerable to disease contamination as well as to carrying diseases harmful to human health, many countries have established mandatory rules on the labelling and registration of livestock. In this regard, cattle, sheep and goats are identified as individual animals; while pork and poultry are usually identified in batches. Even in countries where the identification of animals is not mandatory, animals for export or for export products usually must have a unique identifier.

9. In addition to safety issues, there are other aspects to consider when producing and marketing food, some of which are also defined in legislation. These include product quality, environmental footprint (CO2, H2O), social conditions, origin and pricing. Furthermore, private business partners can also demand additional specifications. Often these specifications are defined in the form of private standards.[1]

10. The integrity of the product can be verified by a physical or administrative inspection, which can result in the product being given a certificate. However, an inspection or a certificate does not prevent all food and feed incidents.

11. In this regard, two types of incidents can still occur:

- Product treatment resulting in hazardous products, harmful to health or the environment; and
- Fraud and counterfeiting, where the product is not what is claimed in the documentation (and due to the false product information, there is no guarantee that the product is safe).

12. The supply chain for food, feed and agricultural inputs is very complex for the following reasons:

- It includes many small producers, traders and processors;
- Most of these commodities and products are bulk products;
- There is a many-to-many relationship between products and between parties (for example retailers purchase products from many producers and producers sell to many retailers); and
- The original producers / suppliers (for example, the farmers) are usually unknown to the processor or trader.

13. As a result, both the consumer and the retailer have limited information about the product and related production processes.

14. To provide all parties involved in the supply chain – including the consumer – with reliable information, there is a trend towards more transparency and traceability in the supply chain. Although transparency and traceability often go together, they are not necessarily the same. However, both transparency and traceability are required in order to evaluate whether the product is compliant with food safety regulations and other requirements. As mentioned above, if compliant, a certificate can then be issued.

[1] An overview of private standards is available at the International Trade Center's Standards Map web site https://sustainabilitymap.org/standardidentify/ (as of January 2019)

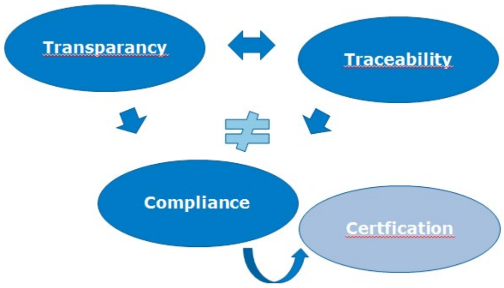


Image 1: Transparency and Conformity traceability

15. Transparency indicates that specific information in the production and supply chain is shared, with whom, and under what conditions. Transparency can include information necessary for traceability, but it may also cover other product aspects such as quality, social conditions, prices and costs.

16. Conformity traceability indicates that specified aspects of an individual product or product batch can be followed or traced back through its supply and production chains (for example, the location of the farm where the product originated from, or the fact that no pesticides were used in its production, etc.). This includes production processes, storage and transport and the parties involved at each stage. Conformity traceability also requires transparency about events in the production and supply chain, in other words information about the what, where, when, who and why, which will vary depending upon the product. Conformity traceability is defined as the ability to identify and locate: 1) the entry point of an asset (product) into the traceability chain, 2) the traceable asset events which occur after entry, and 3) the exit point when the asset leaves the traceability chain.

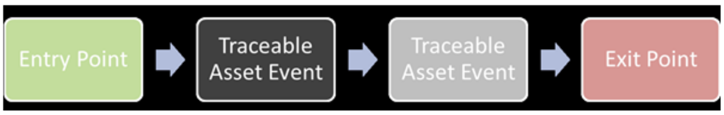


Image 2: Steps of conformity traceability

17. Theoretically, it is straightforward to integrate the traceability chain into product supply chains using a distributed database system such as the blockchain. In reality; however, the situation is more complex.

18. In the food supply chain one-dimensional supply chains do not exist. This means that, in most cases, instead of a chain structure there is, a network structure which can vary in time and over product batches. There can also be many entry points and many exit points. This creates two difficult questions:

1. What is the main entry point? The chicken or the egg? Or the chicken feed, or the harvested crop used for the feed?
2. What is the end point? The egg on the shelve, the chicken meat in the soup, or the chicken dung which is input for the harvested crop?

19. In answering these questions, the best option is to consider the supply chain as a supply network in which supply chains constantly merge and separate, and which includes circular networks.

## B. Food integrity challenges

### I. Conformity traceability

20. Depending on the characteristics of a product there are different traceability models.

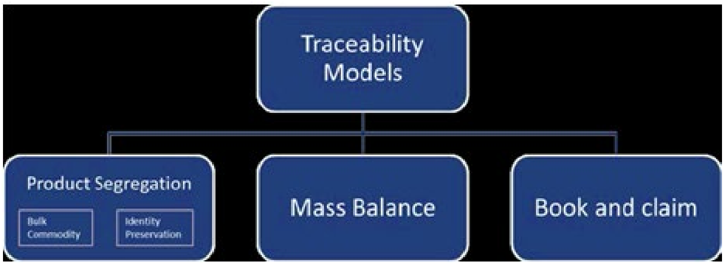


Image 3: Conformity traceability models

21. The product segregation model is used in two situations.

- In the case of bulk commodities, certified material from different suppliers can be mixed. This is used for fruits and vegetables.
- In the case where there is both certified and non-certified products, these should be segregated throughout the supply chain, and the product must be traceable from grower to retailer. This is used for fair trade in bananas.

22. Using mass balance methods, the policy claim is disassociated from the physical tracing of assets. In this method, the policy claims are validated for each asset before it is aggregated into a larger quantity and, as a result, the policy claim is also valid for the mass balance (i.e., accumulated assets), even though individual assets cannot be traced. The aggregated quantity must, therefore, have a well-defined state, linked to the relevant policy claims such as “organic”, “fair-trade”, etc. This is used for cotton, sugar, cacao, tea.

23. In the book-and-claim method there is a free flow of certified and non-certified assets, and no segregation of assets. Instead, a certifying organization sells certificates for X quantity of goods to companies who can then label their product as supporting the good practice in question. The money from the sale of certificates is then used to provide a premium over the market price to growers who are certified as using the good practice, thus providing an incentive for other growers to be certified. The certified product is placed on the market where it is mixed with non-certified product and it is the mixed product that is actually sold. This method is typically used when the production and market conditions make it impractical to sell certified product that has been segregated from non-certified product. At the same time, this method requires audit trails in order to demonstrate that for every certificate sold, certified growers have been compensated for the associated quantity of certified goods. This method is used for soy and palm oil.

24. Product segregation requires advanced Information and Communication Technology (ICT) implementations, in which the farmers and Micro-, Small- and Medium- Sized Enterprises (MSMEs) participate. It is used for high-risk and delicate products, such as fresh food. Mass balance and the book-and-claim, on the other hand, require less advanced ICT systems. This is because they are based on a set of rules and require only periodic auditing by stakeholders. As a result, one factor that must be taken into account is the ICT capabilities of participants in agricultural, fisheries and food supply chains – which vary greatly.

25. Conformity traceability also requires information about the assets, information about the what, where, when, who and why. To specify the asset and link it to events, each of the following must have a unique identifier: the product, party, location, transport and process. Each event that affects the traced asset should thus be registered, and the registered data must be accessible for authorized partners in the chain or network.

26. The production and supply chain can be very complex and the evaluation of product data, in order to establish if policy or practice claims are correct, requires a high level of expertise in a given production stage or a product domain. Because evaluation is a time consuming and expensive process, it is common practice to use certificates to prove the

characteristics of a product. These certificates can be of actual products or of specified stages in the production process and/or the supply chain. The certificate states that the product meets the specified characteristics.

27. In general, on-farm production is considered and analyzed as a separate stage, outside of the supply chain. This production stage includes the on-farm growing, raising or breeding processes, and all the inputs used including: fertilizers, chemicals, medication, seeds, labor, water and energy. In plant production, the end of the production stage is the harvested crop and stored plant produce. In animal production, the end is the delivered raw milk, egg or wool. In animal husbandry for meat production, the end of the production section is the killing of the animal.

28. The supply chain stage for plants includes the processing of the plant produce, packing and transport up until arrival at the retailor. For animal products and meat from animal husbandry, this includes the processing of milk, eggs or wool, the slaughter and further processing of the animal, and the packing and transport up until arrival at the retailer.

29. Along the supply chain, many agricultural products and by-products leave the food supply chain (i.e., leather, corn used for methanol, etc.) or are not part of it at all (i.e., wool, cotton etc.). Many plant and animal products and by-products are thus used in non-food sectors. Some of these also require traceability (for example, cotton that is labelled "organic" or clothing that is "fair trade") and parts of these traceability information chains that go back to the producer of the goods may incorporate information that is also used in food supply chains (for example for palm oil which is used both in food and cosmetics).

## II. Identifiers for producers and products are a prerequisite for traceability

30. In order to implement traceability, all parties involved in the production and supply network must have a unique electronic identity with a unique identifier as either a person or as a legal entity. In addition to this very basic condition, it is better and often required to give unique identifiers to the products or produce being traced and to their location(s) (i.e., farm, field, storage, processing plant, etc.).

## III. Primary production registration (of farm processes)

31. The buyers of a farm product require a large set of production data from the farmer including which inputs were used, why and when. Buyers need this product information in order to show, or even prove, that a product meets the required quality standards and is safe for its intended use. Information is also needed for logistics and process planning. This results in a large amount of data with a complex structure. For electronic exchange, several standard electronic messages are used, such as the UN/CEFACT messages eCROP, eDAPLOS or eLAB, or nationally agreed of business messages.

32. These messages are exchanged between the farmer and the first buyer. When information is needed for use further on in the supply chain, a product is typically given one or more certificates.

33. Between the farmer, the farmer's suppliers and the buyers, four types of information are important:

- Inputs, processes and output data;
- Certificates (of quality and/or characteristics) for the inputs, processes and/or resulting produce;
- Logistics for production inputs and outputs; and
- Financial aspects such as payments, insurance, wages.

## IV. Industrial processing registration (for animal products, fish, meat, dairy or non-food and plant products, food, feed, non-food seeds, fibers)

34. The input for the processing industry is bulk commodities. Even in the case of slaughtering individually identified animals, the slaughter process is handled in batches.

35. One characteristic of the processing chain is that many partners in the chain purchase from multiple suppliers and sell to multiple customers. All production batches are identified, and production data is recorded. Depending on the type of product, products and batches are kept separate (i.e., individual identification) or are traced with either mass-balance or book and claim systems (as described earlier).

36. In food supply chains, all parties comply with the relevant track and trace regulations.

37. The first processors who obtain raw produce from a farmer or trader demand all the relevant product information from the farm. However, the output from these first processors is usually no longer linked to this detailed raw product information, except for some product class/status information (i.e., organic, Fairtrade, MSC, etc.), usually supported by a certificate. Based on these certificates, product status can be maintained as the product moves through the whole production – supply chain).

38. In the case of products presenting possible health risks, the processors can or must be licensed. For example, in New Zealand, only licensed parties may produce and process meat for export.

39. Process information is usually not shared in the supply chain, except basic information such as processing / packing date, “best before date” and obligatory information such as ingredients, allergens, and the packing station.

40. Product traceability does not guarantee that all product information is available in the supply chain or network.

41. The above results in low transparency in the product and supply chain about the product’s characteristics, source of origin and other qualities. In turn, low transparency creates opportunities for unfair, illegal or even dangerous practices, as well as for keeping these practices undetected.

42. These opportunities introduce food and feed safety risks, environmental risks, and economic risks through fraud, illegal competition, etc.

43. These risks can be partly eliminated or reduced by using certificates. One approach is to have a well-structured production and supply chain with known and safe partners which have an agreed level of transparency. At the same time, these partners’ characteristics are often confirmed through certification. Another approach is to undertake inspections at various stages in the production processes and supply chain or network. This involves physical and administrative inspection activities, and often results in certificates as well.

44. In all these solutions, certification is an important key to food and feed safety, and to fighting unwanted or illegal practices.

45. Certification has four aspects:

- The certification process;
- The issuance of the certificate;
- The exchange of the certificate between parties; and
- The link maintained between the certificate and the physical asset.

## C. The Potential of Blockchain

### I. Certification

46. The certification of an agricultural product requires inspection. The subject of the inspection can be the product itself, the production location (i.e., the farm, field, warehouse, processing plant) and/or the identity of the producer (i.e., farmer, organization). It may include a physical inspection and/or an inspection of documents. A physical inspection results in a report, which can be used further in the certification process. An inspection may also be only of documents. All the documents used in or resulting from the inspection process result in questions such as: Are these documents reliable? Which party has created or issued the document? Does the document cover the related assets? Is it the original document?

47. The use of paper documents requires special procedures to guarantee the value of the documents. These procedures can be time consuming and expensive. The use of paper documents also provides many possibilities for improper handling and fraud.

48. Instead of paper documents, electronic documents can be used. When electronic documents are generated by the automated recording of activities or by a fully automated administration, the abuse of documents can be greatly reduced or eliminated. The transfer of paper and electronic documents between different parties is still a point of risk. In the transfer of data, the history of a document can be lost, and with it the possibilities for verification of the document.

49. Therefore, blockchain technology and processes which take advantage of this technology can increase the reliability of all documents used in the certification process. Blockchain applications can also provide possibilities for verifying the actions of involved parties. The table grapes pilot (see VIII) shows the possibilities of a private blockchain implemented with a smart contract.

50. In such a structured supply chain the participants can have assigned roles based on defined credentials. For example, based on what their credentials allow:

- A farmer can upload his product documents to the Enterprise Resource Planning system (ERP), which uses blockchain technology to implement validation;
- The auditor can inspect and grant a certificate;
- Traders and retailers can retrieve product information and certificates from the ERP.

51. The exchange of certificates is a critical process. A certificate is a valuable document which is vulnerable to errors and fraud. To prevent fraud, additional measures are typically required. These vary from authentication marks on paper documents, to encryption, hash totals and digital signatures for digital certificates – sometimes in combination with secure process arrangements such as the use of designated send and receive stations. Even then, there are possibilities to misuse a certificate in other business transactions or in other supply chains.

52. In a supply chain where this information is shared using blockchain technology, the validity of the certificate issued on the blockchain can be verified and the certificate cannot be re-used outside of the specified supply chain.

### II. Track and trace

53. There are standards available for track and trace, such as ISO EPCIS (ISO/IEC 19987:2015) and the UN/CEFACT T&T standards for track and trace of animal traceability and traceability of primary natural products. Based on solutions like those using these standards, many systems for track and trace are used in the agricultural business today.

54. The question remains: what is the added value of blockchain technology for the track and trace process? One issue in the track and trace of a product, is the reliability of the track and trace data. This has two aspects:

- a continuous chain with no missing events where data is captured and
- the quality of the data recording and data processing of each node.

55. For both of these issues, blockchain technology can help.

56. For real traceability, a continuous track and trace chain is required. Every relevant event should be recorded, regardless of the type of traceability model used. A blockchain itself cannot enforce continuous tracking and tracing in a supply chain. On the other hand, blockchain technology can verify when, where and the content of each event that is recorded, so when used at each node in the supply chain, the blockchain can verify the track and trace record of a product from the supplier to the last node where data was recorded, which could be the final customer.

57. For the second aspect, the quality of the recorded data and data processing, blockchain technology can provide a key solution. In a standard track and trace system it is not necessary to provide business partners with the track and trace data for a product in real time or even near real time. This provides opportunities for the hidden correction or manipulation of the data. In other words, the administration of the track and trace system can be used to cover up fraud through the manipulation of recorded data on processes and products.

58. With blockchain technology, data corrections can be possible; but these corrections are transparent to all users of the blockchain who will see both the original data and the changes.

59. Blockchain technology does not prevent poor data quality. Also, fraud is not eliminated with blockchains. But within a supply chain supported by blockchain, fraud will be difficult – provided that all conditions are fulfilled, such as proper identification of the product, location and parties together with the proper authorization of parties.

## III. Sensors and Internet of Things

60. Sensors are very important in agriculture, fisheries and food production. They are used everywhere: on farm equipment, feeding robots, milking robots; on animals to monitor animal conditions, health and location; in storage to monitor climate conditions; in processing; and in transport. Sensors can produce large amounts of data. Blockchain technology is not very well-suited to securing and storing substantial amounts of data.

61. The amount of sensor data can be reduced if only sensor values that meet triggering criteria are registered (such as bypassing a minimum or maximum temperature, if a container has been opened, if electric power has been interrupted, etc.). Also, it is possible to register certificates on a blockchain for a product or process based on recorded sensor data sets (for example, to certify that, during transportation, goods were never exposed to temperatures outside of a specified range). This results in a small amount of data to be recorded in the block chain.

## IV. Transport

62. The movement of goods and a product's condition during transport are critical issues for track and trace, for food safety and sanitary reasons. Based on transport events, the next step in the transport, storage, production process or administrative process can begin. With blockchain technology the integrity of this event recording can be improved.

## V. Process improvements

63. Sensor results and event records can be used for the automation of both technical and administrative processes. This is already common practice for processes within a location or within a single production entity or enterprise. The exchange of sensor results and event records between business parties can contribute to enhanced business and process automation. A key element is the reliability of the exchanged data. With blockchain technology this reliability can be greatly increased. As a result, it is possible to use this data to trigger the next physical and/or administrative business step with the next partner in the chain. In particular, the linkage of an administrative process, such as a payment, with a sensor result and an event record can reduce payment delays in the supply chain. To take advantage of these opportunities, the use of blockchain technology in combination with smart contracts is required.

## VI. Smart contracts

64. A smart contract is a small program (algorithm) which defines business rules to be executed when a blockchain transaction is performed. Depending on the values of a transaction and the parameters established in the program, a smart contract triggers one or more actions. This automatic operation is possible because the source and the quality of the data in the transaction is known and trusted as a result of its validation and secure registration in a blockchain.

65. With a smart contract, you can register basic information in the blockchain which cannot be altered. Examples of such information includes product characteristics and product certificates. This data can then be used for validation and evaluation purposes and can be input for the automated next step(s) which are triggered by a smart contract when it processes a transaction. With a smart contract, transactions as well as the smart contracts which process them and the specified in advance processes which they trigger, are auditable by all parties that have the appropriate consultation rights on the blockchain.

66. Examples of automated processes that can be based on smart contracts are:

- Automated sorting and grading of coffee beans, resulting in automated pricing and billing of the coffee batch.
- Fast payment for eggs to the farmer, when the batch of eggs has been delivered to the retailer, thus eliminating manual administration by several intermediate parties (i.e., packer, gross trader).
- A fair price payment to coconut growers, which can be verified by the consumer of the fresh coconut.
- The certification process and the verification of the certificate (i.e., global gap and organic) of table grapes.
- Automatic payment of some farm support – animal events (i.e., birth, dead, transport) have to be declared via animal event registrations according to legislation. Based on this event registration, automatic payments can be made in accordance with farm-support programs (i.e., subsidies for holding sheep, premium payments for holding traditional cattle species; in the dairy industry premium payments for milk originating from certificated organic dairy farms, etc.).

## VII. Linked data

67. Because the data on a blockchain must be copied to all nodes on the blockchain (this is what makes the data immutable) and writing data onto a blockchain has a cost (this is the incentive to the nodes to create more blocks and store enormous amounts of data), a blockchain is not very well equipped to host large product datasets, or high volume, low

value data. It is more efficient to include in a blockchain only a link to the appropriate data and a calculation (i.e., hash) in order to prove that the content of the data has not been changed. The location for linking to the data is identified with a Universal Resource Identifier (URI).The URI is associated with a hash which is the result of a calculation done on the data at the URI location and serves as a proof that it has not been changed. Sometimes these two pieces of information are also accompanied with a timestamp which indicates the time at which the hash was recorded. The URI can be registered as part of a blockchain transaction or referenced in (or used by / created by) a blockchain smart contract. Usually, the data which is linked using the URI is not part of a distributed ledger. It may be part of a conventional centralised data store or database.

## VIII. Data ownership and data rights

68. Data ownership, data access, and other data rights are an important issue in all industries that use information technology, including agriculture. Blockchain technology supports the development of applications that clearly differentiate between data ownership, data access, data use and other rights. In the agriculture industry, the standard is that the producer of the data is the owner. For example, in the plant and crop case, the farmer is the data owner. The owner decides who has access to the data and what permissions are granted (for example, permission to read, process, forward, etc). In a blockchain it is possible to govern the rights to data on the blockchain, by assigning different roles to blockchain participants. This is also possible for the combination of a blockchain with linked data as described above.

## IX. Blockchain’s impact on markets, opportunities to use blockchain for trade

69. With blockchain technology, transparency in the food supply chain can be improved. It provides the possibility for supply chain partners to have detailed and reliable information about product specifications, qualities and pricing. In addition, consumers may have access to this product information. Of course, whether or not this information is shared, and with whom, depends upon the data permissions that are defined for each stakeholder in a blockchain.

70. The possibilities offered by blockchain technology can have a big impact on production and trade. They can:

- Enhance the fair pricing of products;
- Better ensure a fair payment to the producer;
- Eliminate fraud and counterfeiting;
- Improve the efficiency of financial processes, i.e. speed up payments and reduce the need for financing;
- Improve the efficiency of administrative processes and reduce administrative burdens; and
- Enhance certification processes, etc.

71. A smart example is the result of a project pilot run by FairFood to support fair pricing and tracing of fresh coconuts from the Indonesian small coconut growers up until the consumer in Europe. In this pilot, the consumer can trace the coconut he purchases back to the individual grower, and the consumer can verify the fair price payment to the grower. This is done using individual identification (i.e., tagging) of each coconut and a blockchain with smart contracts. Using this system, all the processes and transactions in the supply chain are registered, monitored, verified and eventually corrected.

72. Although blockchain technology may be complex, once trade agreements are set and defined in smart contracts, it is easy to implement, as evidenced by different pilot projects. For example, in the coconut pilot, even in a remote area this blockchain transaction could be done. For the grower the only requirement was to have access to a smart phone and have an e-identity.

73. Blockchain technology can also enhance the opportunities provided by the sustainable network and other initiatives to promote fair trade and environmentally responsible agricultural practices. As sustainable networks provide information about the grower and his farm, blockchain technology can add secure transactions and provide verifiable information about products and transactions.

# Section VI: Energy trade

## A. Introduction: Changes in the energy industry

1. The energy industry is passing through a seismic shift. Several things illustrate this, including the ratification of worldwide regulations to reduce the effects of climate change; cheaper solar panels and batteries now encouraging consumers to become producers; new technologies like the Internet of Things (IoT) enabling intelligence in households; and, also, hyper-connectivity with the Internet and other devices. A report from the World Energy Council has identified topics of critical uncertainty for the energy industry such as the global climate framework agreement, energy access, energy affordability, extreme weather risks, corruption and terrorism, among others[1]. In order to provide a simpler schema of the changes and challenges in the energy industry, the following three concepts can be identified:

- De-carbonization;
- Decentralization; and
- and Digitization.

2. These are also known as the 3D's of energy "Grid 2.0". The disruptions caused by blockchain technology intensify the need for changes that the energy industry is already going through.

### I. De-carbonization

3. The Paris Climate Agreement which entered into force on 4 November 2016, has now been ratified by 185 countries as of February 2019 . Among other objectives, this agreement aims to mitigate the effects of global warming; and, even though each country determines its own level of contribution, the Agreement is expected to discourage the use of fossil fuels for energy production on a global scale[2].

### II. De-centralization

4. Centralized energy production is inefficient because this leads to losses incurred during transmission and distribution. Furthermore, this issue affects, in a higher proportion, low income economies (18 percent loss) as compared to high income countries (6 percent loss)[3]. In addition to wasted energy, the lack of resiliency is an even more important problem because natural disasters challenge the stability of electricity grids as seen recently with Hurricane Harvey[4] and Hurricane Irma[5]. In fact, it was the disruption caused by Hurricane

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[1] World Energy Council. (2017). World Energy Issues Monitor. London: World Energy Council. Retrieved 09 09, 2017, from https://www.worldenergy.org/wp-content/uploads/2017/04/1.-World-Energy-Issues-Monitor-2017-Full-Report.pdf (as of January 2019)

[2] Paris Agreement. (2017, 09 04). Retrieved from United Nations Treaty Collection: https://treaties.un.org/pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXVII-7-d&chapter=27&clang=_en (as of January 2019)

[3] OECD/IEA. (2014, 09 09). Electric power transmission and distribution losses (% of output). Electric power transmission and distribution losses (% of output). The World Bank Group. Retrieved 09 09, 2017.

[4] St. John, J. (2017, 08 28). Hurricane Harvey Is Putting Texas Grid Resiliency to the Test. Retrieved from Green Tech Media: https://www.greentechmedia.com/articles/read/hurricane-harvey-is-putting-texas-grid-resiliency-to-the-test (as of January 2019).

[5] Pounds, M. H. (2017, 09 10). More than 261,000 homes, businesses without power from Hurricane Irma. Retrieved from Sun Sentinel: http://www.sun-sentinel.com/news/weather/hurricane/fl-bz-fpl-irma-power-outages-20170908-story.html (as of January 2019)

Sandy which motivated the authorities from the State of New York to encourage the construction of micro-grids with the aim to improve resiliency[6]. One result has been the inception of a blockchain-enabled project which is described further below. Finally, the emergence of micro-grids will require different network configurations in order to compensate for the lack of central distribution. This includes the interconnection of micro-grids and, given the nature of such network structures, they will probably also include cross-border micro-grid interconnections, thus blurring national borders and the grid's sovereignty, in exchange for a more efficient flow of electricity and stronger resilience.

### III. Digitization

5. It has been said that Alexander Graham Bell would not recognize the telephone systems of today, but Thomas Edison would fairly easily identify his contributions in today's energy grids. This is not entirely true[7] but it does say something about the perception of breakthroughs and innovation in the corresponding industries. While telecom companies have been disrupted multiple times in the transformations leading from the telegraph to wireless 5G, during the same period, energy companies have continued doing business based on the same principles. They have been relying on long Return on Investments (ROIs) and stable regulations reflected in computer systems that are highly customized with hard-to-change business rules. This is easy to understand because the digitization of utility infrastructure is a double-edged sword. On one hand, it brings affordability and transparency to financial and administrative processes, and, on the other hand, it makes them an attractive target for highly sophisticated cyber-attacks.

## B. Blockchain features with direct impacts on energy markets

6. The following is a list of blockchain features that have the potential to directly impact energy markets.

- **Peer-to-peer (disintermediated) access to electricity trading orders on local, national and international markets**: Energy trading involves multiple actors and multiple consecutive steps, each transaction involving different terms and conditions that enable partners to work together. Having no central authority that controls the network makes business more efficient and cost-effective. It also makes it difficult for members to make secret agreements that would result in the blockchain making transactions that are in their favor and to the detriment of other participants. This is because the majority of participants need to agree to each transaction and, at least in the most popular public blockchains, this would require obtaining the agreement of thousands.
- **Fault tolerant network and automatic replication of critical trading data and information**: There is no single unique server, therefore the network is more resistant to being taken down. This is necessary for the national security of every country in order to ensure the availability of electricity to vital infrastructure such as road traffic management and hospitals.

[6] Jones, K. B., Bennett, E. C., Wenhui, F. J., & Kazerooni, B. (2017). Beyond Community Solar: Aggregating Local Distributed Resources for Resilience and Sustainability. In F. P. Sioshnasi (Ed.), Innovation and Disruption at the Grid's Edge: How distributed energy resources are disrupting the utility business model. (Kindle ed., pp. 64-79). Walnut Creek, CA, USA: Elsevier;
See also: Lacey, S. (2014, 06 10). Resiliency: How Superstorm Sandy Changed America's Grid. Retrieved from Green Tech Media: https://www.greentechmedia.com/articles/featured/resiliency-how-superstorm-sandy-changed-americas-grid (as of January 2019).

[7] Bush, S. F. (2014). Smart Grid: Communication-Enabled Intelligence for the Electric Power Grid. Chichester, West Sussex, United Kingdom: Wiley - IEEE.

- **Smart contracts that automate the processing of electricity trading data, production/consumption data, price agreements, administrative and legal paperwork**: A smart contract is computer code that permanently runs in each network node. It contains precise instructions on when to perform an action (e.g. payments) according to specific events (for example, the receipt of specified data or approval of a responsible party). This feature alone has the potential to reduce the administrative cost of syncing between partners and should result in a streamlined, simplified service to the end-customer.
- **Cryptographically secured identities to ensure legally binding agreements**: The combination of cryptographically secured identities so that no one can pretend to be someone else, with the immutable nature of blockchain records should bring a solution to the legal nonrepudiation problem. In other words, "Alice cannot send a message to Bob, and then later deny ever sending it."[8] This function will be used primarily to make sure that traders and consumers of the end-product really are who they claim to be and that their commitments are authentic.
- **Tokens that commoditize energy production/consumption**: The cryptocurrency tokens commonly known as ERC-20 tokens are a consistent set of logic contained in a smart contract. Each tokens within a defined token type is worth the same amount as all other tokens of that type, so they are the closest possible thing to a standardized digital asset. Tokens can be defined to represent (i.e., act as a proxy for) a standard unit of something, such as energy, which can then be traded. The cryptographic techniques embedded in the network, help to avoid the double-spending of such digital assets, protecting users from bad actors that intend to defraud the system in order to obtain an unfair advantage in the trading, production and consumption of energy units.

## C. Opportunities to use blockchain for energy trading

7. Within the context of the energy industry, and taking into account the previously described features of blockchain, the following are realistic opportunities to use blockchain in energy trading.

### I. Blockchain-enabled Internet of Things and smart contract-enabled peer-to-peer energy marketplace

8. In April 2016, two related projects were launched in Brooklyn, New York in the United States for the installation and setup of a local community micro-grid, and the establishment of a decentralized trading application platform. These were, possibly, the first real-world pilot projects for blockchain managed micro-grids. They have since moved past being proofs of concept and continue in operation.

9. These two projects demonstrated the use of Internet of Things (IoT) devices like blockchain-enabled smart meters, to track the production of solar panels, upload this data onto a public network (Ethereum) and then trade the energy in question on a blockchain network in a local energy market[9]. This concept allows neighbors to purchase electricity produced in their community creating a local energy economy. It is important to note that the realization of such a project was only possible due to the de-regularization of energy trade.

[8] Bruce, S. (2004). Secrets and Lies: Digital Security in a Networked World (Kindle ed.). Indianapolis, Indiana, USA: Wiley Computer Publishing.

[9] LO3 Energy. (2017). LO3 Energy Projects. Retrieved 09 09, 2017, from LO3 Energy: http://lo3energy.com/projects/ (as of January 2019).

This de-regularization and incentives to construct micro-grids in the state of New York were motivated by the events following Hurricane Sandy[10]. Similar services are now being offered in Australia and New Zealand.

## II. Blockchain-enabled Internet of Things and smart contracts to enable a machine-to-machine energy economy

10. This case is similar to peer-to-peer energy markets but instead of performing transactions among households, this application would allow a single smart device to purchase its own electricity from another device (Machine to Machine – M2M). The purchase would be made based on forecasts of the smart device's own consumption, and would be negotiated with another smart device (i.e., a smart battery) that can fulfil the forecasted demand in the desired period. This transaction may occur without any human intervention ; however, the history of such transactions can still be registered on the blockchain and later accessed by human auditors.

## III. Establishing the foundations and infrastructure for future energy applications

11. As the energy sector starts to modernize, and technology start-ups start to enrich the ecosystem, it will be necessary to provide a testbed and a launch platform that can host digital innovation in the form of pilot projects. Additionally, compatibility will become an increasingly hot topic because applications and technologies developed in different parts of the world need, increasingly, to interact. The fear of blockchain islands will hopefully be addressed by new technologies to interconnect completely different blockchain networks. The development of standards such as those developed by UN/CEFACT at the data and process level will also support compatibility and interconnectivity. The Web Energy Foundation is a private consortium of energy companies and blockchain start-ups founded in Zug, Switzerland with the aim to develop and open-source IT infrastructure and blockchain technology that is specific to the energy sector[11] and there are also private sector blockchain network initiatives[12].

## IV. Blockchain smart tokens to record, transfer and avoid double spending of *carbon credit* on energy trading markets

12. "The Paris Agreement includes provisions that can advance carbon markets in two ways: by ensuring there is no double counting when countries engage in emissions trading, and by establishing a new mechanism to facilitate trading."[13]. Blockchain could support these enforcement provisions. For example, they could be written into smart contracts to automate cap restrictions on energy trading. Additionally, regulators and society in general are

[10] Woyke, E. (2017, 04 19). Blockchain Is Helping to Build a New Kind of Energy Grid. Retrieved from MIT Technology Review: https://www.technologyreview.com/s/604227/blockchain-is-helping-to-build-a-new-kind-of-energy-grid/ (as of January 2019);
See also: Cardwel, D. (2017, 03 13). Solar Experiment Lets Neighbors Trade Energy Among Themselves. Retrieved from New York times: https://www.nytimes.com/2017/03/13/business/energy-environment/brooklyn-solar-grid-energy-trading.html (as of January 2019).

[11] Rocky Mountain Institute. (2017, 05 08). Energy Web Foundation Launch. Retrieved from Rocky Mountain Institute: https://www.rmi.org/about/news-and-press/press-release-energy-web-foundation-launch/ (as of January 2019).

[12] PowerLedger. (2017). Powerledger Whitepaper. Powerledger. Retrieved 09 09, 2017, from https://powerledger.io/wp-content/uploads/2017/07/Power-Ledger-Whitepaper-3.pdf (as of January 2019).

[13] Mansell, A. (2016, 02 19). What's ahead for carbon markets after COP 21. Retrieved from International Centre for Trade and Sustainable Development: https://www.ictsd.org/bridges-news/biores/news/what%E2%80%99s-ahead-for-carbon-markets-after-cop21 (as of January 2019).

demanding transparency through guarantees of origin for carbon that is traded. As with any other certification, it is important to ensure the genuineness of such attestations[14]. One possible solution would be the creation of a digital asset that can be implemented using blockchain smart tokens in order to attest to, track ownership of, as well as avoid double spending of carbon credits. This use case is different from projects which reward solar energy producers with "solar credits" which can then be used as virtual currency and exchanged for its equivalent value in fiat money (USD, EUR, etc.). This last kind of token/coin can also be used as a means of payment to buy electricity back from a network of prosumers.

## V. Blockchain smart contracts for auditable, automated pricing and billing in energy trading

13. Electricity has some very distinctive features:

- First, it cannot be stored, which means it either must be consumed immediately or it must be converted into a different state using chemical batteries;
- Second, the quality of the product (i.e., electricity) is exactly the same no matter how it was produced; and
- Third, the cost of production depends on the geographic location, distance to points of consumption, time of the day in which it was produced/consumed, source of production (i.e., renewable, fossil fuels), etc.

14. These factors make energy pricing and trading a relatively complex process compared to the trading of other assets[15]. It is obvious that traders have a strong desire to eliminate costly errors produced by miscalculations, and consequently attempt to automate the market as much as possible. Blockchain has already been used in a similar case for cash settlements in the financial industry[16]. One possible approach would be the research and testing of a national or supra-national energy market that processes pricing and billing, using smart contracts to manage the process in an automated way. At the same time, such a market could create transparency for traders and auditors both ex-ante via the auditing of smart contracts, and ex-post auditing of blockchain transactions.

## VI. Blockchain smart contracts to reduce administrative costs of self-consumption energy communities and encourage zero-net-energy buildings

15. Many countries have started initiatives to encourage so called Zero-Net-Energy Buildings. These are buildings that can produce the same amount of energy as they use during a set period of time, thus effectively netting to zero in their metering. In Switzerland, a new law was passed in May 2017[17] in which tenants of a building can establish a self-consumption energy community recognized by the local electricity retailer. This allows a producer (i.e., the building owner) to install solar panels and sell this energy to the tenants for a price that

[14] Jensen, J., Drabik, E., & Egenhofer, C. (2016). The disclosure of guarantees of origin: interactions with the 2030 climate and energy Framework. Brussels: Centre for European Policy Studies - Energy Climate House.

[15] Sioshansi, F. (2017, 08 18). How electricity will be priced in the future. Retrieved from Energy Post: http://energypost.eu/how-electricity-will-be-priced-in-the-future/ (as of January 2019).

[16] Neghaiwi, B. H. (2017, 08 31). Six big banks join blockchain digital cash settlement project. (J. Gaunt, Ed.) Retrieved from Reuters: https://www.reuters.com/article/us-blockchain-banks/six-big-banks-join-blockchain-digital-cash-settlement-project-idUSKCN1BB0UA (as of January 2019).

[17] Confédération suisse. (2017, 03 21). Promouvoir les énergies renouvelables. Retrieved from Confédération Suisse - Département fédéral de l'environnement, des transports, de l'énergie et de la communication DETEC: https://www.uvek.admin.ch/uvek/fr/home/energie/strategie-energetique-2050/energies-renouvelables.html?_organization=801&_startDate=01.11.2010&_pageIndex=0 (as of January 2019).

is attractive to both the tenants (i.e., cheaper than the grid) and the solar producer (i.e., higher price than feed-in tariffs). Once the community has been created, the community manager oversees the electricity billing for each community participant. The related administrative costs can affect the profitability of such ventures, therefore, products and services are now being offered in the Swiss market to help reduce these costs using blockchain[18].

## VII. Blockchain-enabled Internet of Things and Smart Contracts to cooperatively manage responses to demand and increase the flexibility of the grid

16. A fundamental principle of electricity grids is that energy production must respond proportionally to demand. The challenge for grid operators is to manage the high level of uncertainty on demand throughout the day as well as within seasons. This challenge forces grid operators to develop complex but imperfect forecast models for demand, and to accept additional costs that give them the flexibility they need in order to compensate for unexpected fluctuations in demand. Such costs include having excess capacity available to meet unexpected peaks in energy usage and having the ability to shut down generators to prevent damage in the case of unexpectedly low usage. The massive adoption of IoT devices within households[19] will enable bigger, better and faster data collection. This will make it possible to synchronize disparate household consumption patterns and to better manage demand in order to reduce the levels of flexibility and related costs required by the grid. Specifically, the future smart home will also be able to send data produced by home appliances to a smart contract, which then coordinates with other households in order to automate schedules of electricity use. Each smart contract will act according to the economic incentives provided by the electricity grid.

## VIII. Scalable fast, Internet of Things-friendly blockchain networks to allow pay-as-you-go energy financed by micro-transactions

17. Developing countries, and especially African countries have demonstrated a remarkable growth in the last ten years. This has been propelled by their leapfrogging others by implementing the most recent technologies in a world with rapid technological advancements. In the case of energy, the preferred solutions implemented by businesses and consumers are wireless, solar and mobile. These solutions compensate for inadequacies in the infrastructure of these countries. However, in spite of all these improvements, a lack of transparency, corruption and abuse of power are still major issues[20] and make it difficult for investors to do business in these regions. Within this context, sustainable business models that enable access to electricity in the poorest regions of the world are being developed[21]. Given that developing regions often suffer from corruption, including in civil law courts, the inclusion of IoT-enabled blockchains could lead to the creation of a transparent, persistent, immutable source of records that supports such business models. Blockchain applications could be designed to keep the transaction costs very low (for example, due to disintermediation there is less room for bribes and extortion). Automation is also important for controlling costs since the monetary value of transactions will be relatively low, while

[18] Alvarado, J. L. (2017, 05 31). Using Blockchain to accelerate the creation of self-consumption energy communities in Switzerland. Retrieved from Slideshare: https://www.slideshare.net/JorgeAlvarado87/31052017meetupblockchainjorgealvarado (as of January 2019).

[19] Gartner. (2017). Gartner Says 8.4 Billion Connected "Things" Will Be in Use in 2017, Up 31 Percent From 2016. Egham: Gartner. Retrieved 09 10, 2017, from http://www.gartner.com/newsroom/id/3598917 (as of January 2019).

[20] Transparency International. (2016). Corruption Perceptions Index. Berlin: Transparency International. Retrieved from http://files.transparency.org/content/download/2089/13368/file/2016_CPIReport_EN.pdf (as of January 2019).

[21] M-Payg. (2017). Our Vision. Retrieved 09 09, 2017, from M-Payg: http://www.mpayg.com/#story (as of January 2019).

the number of transactions will be very high. Automation comes at the cost of needing an Internet connection but this can be partially solved with the use of batch synchronization. Such a technology solution could provide a stronger level of confidence for the legal enforcement of agreements to companies. At the same time, this could also reduce the operating cost of performing transactions on a global, secure network.

## D. Challenges of using blockchain for energy trading

18. This section discusses general concerns in the energy industry, which are a result of the inherent characteristics of blockchains. These are also a concern for many other industries.

### I. Governance and regulatory frameworks for national and cross-border energy trading

19. Lawyers, programmers, visionaries and regulators are having heated debates surrounding the question of whether the code can be the law[22]. Specifically, the debate centers on whether people could rely exclusively on the authoritative execution of a smart contract to enforce agreements without involving previous paper-based legal engagements. For example, there are demos which have illustrated a templating tool to generate smart contract code based on specific keywords and jargon[23]. However, in all these cases, trust and/or enforceability must be present. Furthermore, questions arise on who, where and what audits and enforces blockchain trades placed between disparate national and international jurisdictions? This discussion is abstract and complex because it requires reconciling both legal jargon and the verification of syntactic and semantic information, which is a topic usually reserved to the fields of computation and mathematics.

20. Energy trading is most frequently carried out across a complex network of electricity highways physically crossing borders. As a result, industry stakeholders are concerned about how blockchain can realistically enable/enforce good governance when code is executed as is and the transmission of electrons involves multiple countries, jurisdictions, languages and foreign financial exchanges.

### II. Electricity consumption and customer data: data ownership, personal privacy, the General Data Protection Regulation.

21. Customers and users are increasingly aware of the sensitive information that Internet companies have obtained from consumer data that is gathered from the use of their centralized databases and services. The smart meters commonly used to provide intelligence to energy-trading platforms further enable the gathering of massive amounts of data produced by the electricity consumer. The EU's new General Data Protection Regulation brings very strict rules with regard to the individual's rights to privacy[24]. This regulation which came into force on 25 May 2018, stipulates that if an organization fails to comply with the rules, they will face a maximum fine of four percent of global turnover, or 20 million euros. One of the

[22] del Castillo, M. (2016, 06 28). The Inventor of the Merkle Tree Wants DAOs to Rule the World. Retrieved from Coindesk: https://www.coindesk.com/ralph-merkle-is-back-and-he-wants-to-resurrect-daos/ (as of January 2019);
See also: Kolber, A. (2016, 10 28). Code is not the Law: Blockchain Contracts and Artificial Intelligence. Retrieved 09 04, 2017, from Youtube: https://www.youtube.com/watch?v=MBKjpRuCvNE (as of January 2019).

[23] R3. (2016, 04 18). Smart contract templates. Barclays' Smart Contract Templates. London, London, UK. Retrieved 01 14, 2018, from http://www.r3cev.com/projects/ (as of January 2019).

[24] European Union. (2017, 09 04). General Data Protection Regulation. Retrieved from EUGDPR.org: http://www.eugdpr.org/eugdpr.org.html (as of January 2019).

most common pitfalls of using blockchain to store personally identifiable information is that the "right to be forgotten" is impossible to implement in a public blockchain.

## III. Intellectual property, partner and energy price agreements embodied in smart contract code

22. Business transaction data on products, clients, sales volumes is often the basis of differentiation or pricing strategies including for energy trading actors. If all data used in business transactions is open to competitors, the commercial or technological advantage disappears. Additionally, there is other sensitive data that should be accessed only by authorized parties (for example, for national security reasons). On public blockchains, access to such data can be reduced using encryption and the storage of data pointers rather than actual data on a blockchain. The level of protection provided varies based on the encryption methods used. At the same time, strong encryption has associated costs, and few of these methods are fool-proof solutions when faced with determined hackers. Currently there are two ways to address these issues in a more secure way:

- First, on a political level by creating a so called consortium that effectively scans potential partners before granting them access to a permissioned network, and
- Second, on a technical level, by creating a permissioned blockchain which consists of privately-owned computer networks and blockchain nodes, which use traditional information technology security design and architecture.

## IV. Electricity trading transactions and the need for interoperability between blockchains

23. The trading of energy does not work in isolation from the rest of the economy. In fact, the results (i.e., the cost of electricity) are reflected in all other trading and economic activities across the globe – except the most primitive forms of barter where neither the product production nor the trading requires the use of electricity. As a result, as more and more economic activity is performed on blockchain networks in all sectors, including electricity, it will be increasingly necessary to establish norms of communication and exchange between blockchain networks. Moreover, the surge of the token economy will bring along new possibilities for exchanges of value across all industries and globally. To support blockchain interoperability and compatibility at both the technical level of data exchanges and the business process level, inter-disciplinary, inter-industry standards must be in place in order to allow a seamless exchange of tokens and the execution of smart contracts so that these can be performed in symphony across organizations, industries and geographies.

## V. Transaction costs, micro-transactions and the problem of scalability for energy retailers and the end consumer

24. Given the mechanics required for the confirmation of transactions on public blockchains, it is very difficult to use them for micro-transactions in a secure, reliable and economically viable manner. Currently, there are no good public-blockchain alternatives that address the cost issues for micro-transactions as well as the speed and volume issues that are often, also, associated with micro-transactions. There are some public distributed ledger solution being developed to address these issues, that do not use blockchain technology, but instead a method called Directed Acyclic Graph (DAG)[25]. This technology is still in its infancy compared to blockchain technologies and, therefore, has not been widely tested. Otherwise, the solutions for scalability and transaction cost tend to push organizations and

[25] See: Popov, S. (2016). IOTA whitepaper. Retrieved 09 10, 2017, from https://iota.org/IOTA_Whitepaper.pdf (as of January 2019);
Also see: IOT chain. (2018, 03 25). Whitepaper. Retrieved from IOT CHAIN: https://iotchain.io/ (as of January 2019).

consortiums into the use of private/permissioned blockchain networks that interact with traditional IT infrastructure and, invariably result in trade-offs between security, speed and transaction volumes.

# Section VII: Tourism

## A. Introduction: The tourism industry and rapid growth

1. The rapid growth of international tourism is quite remarkable. The 2018 Annual Report of the United Nations World Tourism Organization (UNWTO)[1] says that international tourist arrivals reached 1,326 million in 2017, the result of a continuous growth of around four percent a year during the past eight years and a seven percent increase over 2016. Tourism is one of the most rapidly growing business domains and will, inevitably, need to make use of the most advanced technologies available in order to accommodate the needs of this growing market.

## B. The historical evolution of state-of-the-art Information Technologies in the tourism industry since the development of UN/EDIFACT

2. The tourism domain has played a leading role in the use of innovative Information Technologies (IT) and has been among the first users of state-of-the-art IT at each stage of their evolution.

### I. From computer reservation systems to Global Distribution Systems

3. In the 1980s major airline companies competed with each other by expanding their proprietary Computer Reservation Systems (CRSs) through the absorption of other smaller CRSs. This evolution was based on using the power of large-scale computers. Around 1990, the major airline CRSs became Global Distribution Systems (GDSs). With the invention of personal computers (PCs) and the need to interconnect with other travel-product supplier systems (i.e., hotel chains, car rental companies, etc.), they realized the need to standardize their business processes by creating relevant messages and data interchanges.

4. Such standardization created opportunities for increased functionality and reduced IT development and maintenance costs. It was at this time when the tourism domain became active in the development of the United Nations Electronic Data Interchange for Administration, Commerce and Transport (UN/EDIFACT). The tourism domain involved a range of industry participants from airlines, railways, hotel chains, major car rental companies, ferries, travel agents, etc. Soon after they started these activities, they realized the need for creating Interactive EDI (Electronic Data Interchange) messages instead of the batch EDI messages which, at that time, formed the main stream of UN/EDIFACT activities.

5. The tourism domain took the main role of developing the interactive syntax rules for UN/EDIFACT by providing user input for their development. Since then, many data interchange messages based on these rules have been developed and are still in use today by the major IT systems in the domain.

### II. From the Internet to mobile communications

6. Around 1995 commercial Internet applications and sites started to come on-line. The United Nations, through its Centre for Trade Facilitation and Electronic Business (UN/CEFACT) supported this movement toward e-commerce with ebXML specifications to make use of XML (eXtensible Markup Language) technologies. Based on the specifications, an entire range of UN/CEFACT SLH (Small-scaled Lodging House) related information process projects were completed by 2012. The output of these projects is now in international

[1] See https://www.e-unwto.org/doi/pdf/10.18111/9789284419876 (as of January 2019)

SLH pilot use, waiting to be commercially used to trade globally traditional, cultural and local lodging houses.

7. With the growing use of smart phones, mobile technologies have become a prevailing factor in the domain since around 2010. XML specifications, in general, have been widely used to make use of PCs and mobile technologies in the domain. The major tourism domain players, (especially intermediaries such as online travel agents) have been using proprietary specification-based XML messages. Their systems have been based around the use of central servers. The architecture of the use of central servers is quite similar to the ones used by GDSs, although they keep the EDIFACT specifications as the basis of the message interchange. Currently, only a few online travel agents and GDSs have a dominant presence in the domain. Their businesses have been so successful globally that it seems to be quite difficult to start up a new business in the domain based on a similar business model.

### III. And now, blockchain and related new technologies

8. Blockchain and related new technologies are being implemented by a number of businesses throughout the world, providing users with the first introduction to these technologies' features and benefits. In the tourism domain, around the world, many proof of concept projects to test these technologies have also been initiated. Most of these technologies are in their initial development stage, but there are many parties who have a great interest in the potential benefits that these could provide to businesses and consumers. The UN/CEFACT Travel/Tourism domain is paying close attention to the progression of these technologies in order to identify an appropriate time to initiate standardization activities with domain knowledge experts and business players which will enable them to implement these technologies more effectively.

## C. Issues in the tourism domain

9. Even though state-of-the-art technologies have been applied to domain businesses, there still remain some issues to be solved, some of which could be addressed by the use of blockchain and related technologies. the following are some of the key issues.

### I. High commission rates

10. Some intermediaries with centralized server systems have been dominating the global travel distribution markets, especially in airline and hotel sectors. They usually require high commission rates from their suppliers, who inevitably increase the costs for end-users in order to cover part of these expenses. As a result, many suppliers suffer from the burden of high costs.

### II. Connecting local travel-product suppliers and customers

11. In every country, local areas provide a huge number of travel products such as: lodging houses, sightseeing facilities, experience activities, food and eating places, etc., some of which are world-class in quality. Customers for these products are not limited only to immediate, local areas but exist all over the world. Nonetheless, the worldwide or countrywide dominant distribution systems may find it difficult to effectively accommodate the vast number of local travel products and associated providers in their systems. Today, it is also recognized that tourists are more prone to visit rural areas in order to enjoy new experience programs in less crowded places. There is, therefore, a need for innovative methods to meet this demand.

## III. Confidence in the existence of local suppliers and customers

12. Despite the common use of websites, both international and domestic customers could find difficulty in confirming the real existence of local travel product suppliers, in the same way that finding individual local attractions or services may be difficult. In addition, service providers need to have confidence in the identity of their guests. They also need to be informed of any changes in arrival times in an effective manner that allows them to manage their businesses.

## IV. Lack of ability to bear distribution costs

13. As the size of suppliers goes down, it becomes more and more difficult for suppliers to pay the cost of distribution through the central server systems used by the dominant online travel agents. If smaller businesses were able to make payments based on a sliding scale linked to their supply capacity, they could afford to use centralized distribution services.

## V. Small payment amounts

14. In many cases, suppliers and buyers have to pay or receive small amounts of money which may be a percentage of a payment (such as commissions). International payments are costlier and take longer to settle in comparison with domestic payments. This is because international payments have to pass through the international banking system. Therefore, when suppliers of rural experience programs or activities, need to settle small commissions with many players and with international parties, the cost and time can either negatively affect them or even make some activities unprofitable.

## VI. Personal information

15. All travel service providers require at least some personal information about their customers. This information needs to be kept securely and be shared safely with other service providers as determined by the needs and conditions of relevant participants and by regulators (if applicable). There are also some cases where service providers (for example a centralized distribution platform) acquire initial customer information successfully but are unwilling to share data with other service providers who need to have access.

## VII. Digital divide

16. The IT capacity of small and medium-sized trade and tourism service providers (SMEs), especially in rural areas, is usually limited. When these SMEs start using IT technology, it is advisable to connect them with useful contacts or organizations who can assist them. This is because rural travel products usually need more detailed information than those in urban areas in order for customers to enjoy their visits. To support rural business players, web sites should be available to them without a large investment in infrastructure. And, at the same time, many rural and remote areas have remained without Internet connectivity for many years and suffer from a shortage of IT technical expertise.

## VIII. The need for new customer rating systems

17. The review systems that are provided by some major information suppliers allow customers to review and give public ratings to their travel service providers. Sometimes, these ratings may reflect misunderstandings or even misconduct with purposeful attempts to influence ratings. However, if travel service providers could keep track of the behavior and special requests made by customers during their trips, they could obtain more appropriate information from customers on how to provide them with more satisfactory services. This new mechanism could protect travel service providers from fraud or security risks.

## D. Opportunities presented by blockchain

18. If distributed ledger technologies could solve some or all of the issues listed above, that would have a great, positive impact on tourism business.

### I. High commission rates

19. If suppliers could access end-users without any intermediaries, they could save a large amount of money. This could decrease the cost of distributing and promoting their travel products. Hence, end-users could get their travel products at a cheaper price. Distributed ledger technologies could be used to create direct sales between tourism suppliers and customers while providing both with the guarantees, previously provided by intermediaries, for payments and services provided.

### II. Connecting local product suppliers and customers

20. The new distributed-ledger technologies could also be very effective in supporting decentralized solutions for the distribution of local travel products. In that regard, customers can emerge from any region of the world. There have already been initiatives, in the form of proof of concept implementations, which would prove the ability to support this functionality. In the future, as these proofs of concept move into full implementation, the industry will be able to better judge their ability for success. Therefore, these new technologies could be expected to provide a wide range of local travel products and information to customers in the future.

### III. Confidence in the existence of local suppliers and customers

21. Once the suppliers of travel products and information are registered in a distributed ledger environment, this information can be kept there as long as the suppliers are active. In addition, customer information can also remain stored once registered. Parties with authorization to access information regarding tourism business players or customers in a distributed-ledger environment, could also be given access to all registered and relevant information.

### IV. Lack of ability to bear distribution costs

22. As distributed-ledger technologies could allow direct communication between travel product suppliers and their users, this could, depending upon the design of the distributed-ledger networks, reduce the distribution cost to a minimum. Therefore, small-sized suppliers could be accommodated well in such networks.

### V. Small payment amounts

23. In the tourism domain many players work harmoniously, with a small payment or commission paid or settled quickly and easily between them at the lowest possible cost. The challenge is when there is need for the payment to be settled internationally, with the associated, elevated fees. In this regard, the distributed-ledger technologies could provide solutions, either through the use of cryptocurrencies or tokens that can be exchanged at a fixed rate for fiat currencies (i.e. currencies issued by central banks such as USD or euros).

### VI. Personal information

24. In some cases, tourism transactions also require the use of confidential information (such as personal information covered by privacy legislation or information related to payments). In applications that use distributed-ledger technologies, this information could be encrypted and saved securely either on a ledger or at an address where the location is saved on the ledger. This last solution offers a double sort of security, because the address of the

data is also encrypted. In addition, a data fingerprint (i.e., in the form of a hash) can also be saved on the ledger so that the veracity (i.e., unchanged nature) of the data can be proven. Authorized participants would then be able to view the data after receiving the related cryptographic keys. This could very well increase the privacy and security of data for all business participants and clients while also providing adequate access.

### VII. Digital divide

25. This issue is not directly related to distributed-ledger technologies, but must be addressed if rural suppliers and customers are to have access to related services and benefits. In some cases, in countries where Internet use is restricted, distributed-ledger technologies could help revitalize travel businesses by offering an alternative. Furthermore, in rural areas everywhere, and especially in developing countries, travel businesses might also lack access to banking systems. They could thus use digital-ledger technologies in order to receive payments from customers or send payments to suppliers without needing to rely exclusively on the banking system.

### VIII. The need for new customer rating systems

26. Distributed ledger technologies could allow the cost-effective tracking of historical data on business players and their customers. Thus, illegal or non-suitable behavior by business players or their customers could also be tracked. Distributed ledger technologies can also be used to safeguard user privacy while, simultaneously tracking customers' travel activities and preferences (i.e., to identify trends). In addition, the technologies can also be used to track customer reviews of their suppliers or of travel products while paying attention to privacy concerns such as the identity of the customer.

## E. Challenges to using distributed ledger technologies in tourism

27. The distributed ledger technologies discussed here arguably have significant merits which should allow them to function well in the future. At the same time, in order to reach this goal, there remain challenges to be addressed, including the following.

### I. Reaching markets as a new tourism domain startup

28. Due to the extremely large and dominant travel product distributors now operating in the tourism domain, it might not be easy to start up new distribution businesses regardless of the technology used, including distributed ledger technologies. For example, obtaining the attention of a critical mass of potential users so that they try a new service even just once, is a daunting task in an industry where the majority of the public go to only four or five, or event fewer well known, existing online travel service providers.

29. At the same time, it is noticeable that initiatives have already been started in the domain. In addition, since a large number of travel products are not in the hands of the big players and remain in rural regions, there is the potential to create a niche for products to be handled by applications based on distributed ledger technologies.

### II. Standardization needs

30. If a large number of separate distributed ledger networks emerge in order to meet the challenges described above, the issue of how they could be interconnected with each other and share information exists. There should be standardized processes and data for exchanging information across distributed-ledger networks and with other, data sources outside of distributed ledgers. This will make it possible to accommodate the need of suppliers and customers to work with a variety of distributed ledger networks and other, linked systems.

UN/CEFACT standardization activities should support these interconnections and data exchanges across separate distributed ledger networks so that they function well in the future.

### III. The role of intermediaries

31. There are a lot of intermediaries in the tourism domain who currently work on distributing travel products. They have been functioning well up to now. But if distributed ledger technologies function much better, suppliers and buyers of travel products could more directly deal with each other. If this happens, then intermediaries will need to re-consider their functionals and services if they are to survive. They need to find good solutions in the future, if not their industry will be profoundly disrupted.

### IV Protecting data securely

32. The private/secret data of individuals and companies must be kept secure and made available only to those who are allowed to do so by the data's owners. Encryption and decryption technologies support this objective but are not adequate by themselves because of their predictable obsolescence (for example, the secure encryption technologies of ten years ago are easily broken today). Therefore, privacy needs to be designed into systems and well-structured and secure infrastructure should be available at all times. Security is essential and must take priority even over reducing the costs of gathering, using, storing and disposing of data.

### V. Development costs

33. There needs to be more public or private channels for raising the funds to start up a business using the distributed ledger technologies. In some cases, the providers have raised funds by creating cryptocurrencies. However, the technical knowledge and, above all, the increasingly complex legal and regulatory environment for such initial coin offerings (ICOs), make this an unrealistic alternative for the majority of startups and SMEs. Therefore, technical, legal and financial assistance to those with good concepts for the use of distributed ledger technologies in the tourism domain would make a big difference.

### VI. Long-term certainty

34. Blockchain is a new technology, and different designs (i.e., protocols) and operating methodologies are constantly being developed. In an industry such as tourism it will be important for both service providers and customers to have a high degree of confidence in the technology and its long-term sustainability. This will require a careful examination of the incentives, financial and otherwise, for their long-term operation.

## F. The future

35. The future of the tourism domain is rather difficult to predict. This is especially true when trying to predict who the winners or survivors among the emerging blockchain systems will be . Businesses with a dominant edge today may, or may not, stay ahead without adapting to the changes that can be brought with distributed ledger technology. It is inevitable to expect the arrival of new players who adapt quickly to these technological changes. However, it is also uncertain whether such models will thrive. What can be said with certainty is that distributed ledger technologies provide opportunities for the new development of tourism services that do not currently exist, and there are an increasing number of initiatives appearing around the globe which look to solve some of the challenges described above. To know the future, we may need to wait and to continue observing the work of current dominant players as well as emerging initiatives. What is guaranteed is that change is forthcoming and that the future will be interesting.

## G. Other references


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# Section VIII: Music and arts

## A. Introduction

1. Artists, music producers and music fans are going to be amazed at how blockchain will revolutionize the music and art industry. In the same way that other industries are leveraging blockchain technologies to cut out inefficiencies and increase profits, the music industry also has a lot to gain from this technology which many believe will revolutionize the way people interact with one another and with organizations.

2. Many music lovers have hailed digitization as bringing democracy to the music industry. At the same time, many aspects of the global music industry, have, paradoxically, remained the same. In 2017, the music industry had revenues of over 17.3 billion USD, 54 percent of which was digital income and reflecting an increase over 2016 of 8.1 percent. On the other hand, it is increasingly difficult for new artists to become known and it remains difficult, if not impossible, for the vast majority of artists to make a living from their work. In addition, those who discover and produce artists are also revenue challenged. Music piracy through illegally downloaded, copied and shared content eats into artists' and music labels' royalties and revenue. Digital streaming services pay artists as little as 0.0003 USD per play (i.e. the artist receives 3 USD after 1000 plays), and the lack of a robust rights management system also leads to a loss of revenue for artists. In addition, it can take up to two years for this revenue to reach the artist.

3. Another area of concern is unpaid royalties, the payment of which is often suspended at various stages for reasons that include missing information on rights ownership. There is also a lack of access to real-time digital sales data which, if available, could also be used to develop strategies for more effective marketing campaigns.

4. In addition, artists can also suffer from the lack of transparency in sales information; so even though Digital Service Providers (DSPs) report a huge volume of streaming transactions, artists may end up receiving payment for only twenty to forty percent of these transactions. This has led to several artists choosing to keep their music off such on-demand streaming services, causing notable gaps in the libraries of popular on-line services.

5. Blockchain can make a significant contribution to these areas by eliminating the need for an intermediary or third party to manage or control information. Blockchains can be used to provide publicly assessable, trustworthy information based on the use of decentralized databases that are distributed across the Internet, maintaining permanent and undeletable records in cryptographic form. In addition, they compute, verify and record transactions using an automated consensus method, a process which cannot be changed once it is agreed upon and implemented. This immutable, distributed and peer-to-peer architecture has immense potential for dealing with the present woes affecting the music industry and its artists.

6. In other words, blockchain technology can potentially revolutionize the way music and art are distributed and consumed.

## B. Some changes that blockchain could initiate

7. A primary area in which blockchain can bring positive change is in the creation of a digital rights database. The identification and assignment of digital rights is one of the key issues afflicting today's music industry.

8. Identifying the copyright of a song and defining how royalties should be split between songwriters, performers, publishers and producers is difficult, and especially so in the digital space. Often artists lose out on royalties due to the complicated copyright environment. Blockchain's immutable distributed ledger system could register agreed upon royalty allocations, in a manner that prevents them from being altered or claimed by others. In addition to the royalties themselves, secure, trustworthy files can be registered on a blockchain containing related information such as the creators of the composition, lyrics, linear notes, cover art, licensing, etc. and the allocation of royalty rights across these parties. Such a system would result in an enormous increase in transparency since this information would be available to all stakeholders.

9. Blockchain technology can also be leveraged to facilitate the automatic payment of royalties through smart contracts. British singer Imogen Heap's 2015 song, "Tiny Human" was released on a blockchain powered site where users could purchase the song using the cryptocurrency Ether. The smart contract encoded in the Ethereum blockchain by this application enabled the proceeds to directly reach the artists as well as the producers, writers and engineers. Such a system removes the need for intermediaries and provides a transparent ecosystem which ensures that all stakeholders receive their fair share of royalties.

10. In addition, the digitization of the music and media industry has left artists and producers to deal with the rampant problem of piracy, with users finding innovative ways to copy, record and distribute content, without compensating the copyright holders. The highly trustworthy security that blockchain technology provides can be utilized to find solutions to prevent unauthorized distribution. There are various options for achieving this objective, one would be to create a unique record which results in a payment every time a song is played, thus preventing the content from being ripped off.

## C. The time for disruption is now

11. Many agree with Nick Mason of Pink Floyd, when he says, "If blockchain technology is going to be the future, we need to dig in and make it happen." The music industry, disrupted by digitization, is currently in a struggle due to age-old structures that are unable to cope with present day digital demands. Today, there is an opportunity for blockchain technology to contribute towards the building of a healthy and robust ecosystem that can benefit both artists and producers

12. At the same time, however, there are challenges which still need to be met in order to realize blockchain's potential in this sector.

### I. Challenge 1: Access and distribution

13. Historically, ownership and access to content has always been an issue. Currently, artists and fans are linked only through major, centralized, music hubs that pass relatively few profits on to artists and charge fans very large fees for access. As a result, artists with smaller reputations suffer and are unable to make a living strictly from producing music. In addition, the established, big-name artists also give up much of their profits to this centralized management. In addition, it is important to note that research shows that playlist makers[1] although driving much of the profit on digital music sites, are never compensated for their research and work.

14. When you buy a book, do you only buy the one physical copy, or do you own the content you have bought?

[1] For example see http://playlists.net/charts (as of January 2019)

15. When you buy a track on iTunes, do you have the perpetual and immutable right to play that song, and can you copy it onto another media? This becomes more challenging when you consider a subscription service, where you pay for access to the platform but then cannot listen to the track anywhere except on that platform

16. One approach to this use and ownership issue, is being developed on an Ethereum-based blockchain. The following is a brief, high-level description of how it works, as an example of the possibilities available. This blockchain platform creates a global ledger with all the music that has ever been uploaded onto it. Then, this layer of music is always accessible, regardless of location or time, and songs that have been purchased are always available to the user for listening or downloading . The platform is completely transparent with all transactions available for public viewing on the Ethereum blockchain. Furthermore, 97 percent of the money received goes directly to the artists. Simply put, the system is designed to move funds to the artists who create the music, rather than to the centralized management organizations and systems that, today, act as expensive intermediaries. Playlist-makers, are credited for increasing user traffic towards artists' works, as well as fans that actively promote their favorite artists, can also earn from their activities on this platform. Therefore, this concept drastically changes the business model of music for both fans and artists, allowing for greater access to more music and in ways that will eventually be simpler than the options offered today.

17. As more people use blockchain and better user interfaces are developed, blockchain-based music platforms could significantly contribute to the digital music industry. In particular, they could make it possible to simultaneously lower costs for users and increase income for artists by reducing the use of large-scale, costly digital music intermediaries through decentralized control and management that is in the hands of artists and producers.

## II. Challenge 2: Commercial viability

18. One big challenge in distributing creative works is making them commercially viable.

19. This can be of particular concern to independent or small artists who do not have full control in managing their works. Case in point: it is estimated that major, centralized platforms acting as intermediaries, receive at least eighty percent of whatever listeners pay for an artist's music. The copyright holders (the singers and songwriters, in this case) only get slim pickings.

20. Big artists might have more clout, and their large sales volumes allow them to make a decent living, but losing a big part of their potential income to the platform can still hurt, considering the effort put into conceptualizing and executing their performance art. By contrast, independent artists often struggle in competition with everyone else in a big platform, unable to raise their profile high enough for listeners to even know that they exist.

21. By reducing the high cost of intermediaries in the music business blockchain technology can increase commercial viability for artists by connecting them directly with their fans and allowing them to earn significantly more revenue from listener payments. For example, in 2015, the artist Imogen Heap used a blockchain platform to deliver tracks directly to fans, while accepting payments in cryptocurrency. This idea has been considered a proof of concept and is being pursued by a range of start-ups, including one launched by Ms. Heap which is looking at how to "shift from our current outdated music industry models, exploring new technological solutions to enliven and positively impact the music ecosystem."

22. In the digital visual arts, commercial viability can also be increased by creating digital scarcity. This refers to the use of blockchain technology to limit the number of legal copies in existence on the digital market (i.e., like a limited-edition print), as well as tracking who owns these copies. This allows a user to verify that there are indeed only a certain number of limited-edition copies of an artwork, that the artwork purchased by the user belongs to

them, and that it was created by a specific artist. Another way that decentralized digital art platforms can support the commercial viability of the arts industry, is by giving a portion of the proceeds to the artist whenever a limited edition digital artwork is re-sold.

23. Such decentralized marketplaces where limited-edition digital artworks can be bought are already being developed .

24. Blockchain technology can also support the commercial viability of traditional fine arts by democratizing fine arts investment. As of 2018, one company allows you to own a fraction of a famous painting by artists which include Picasso, Warhol, Monet, and many others. Galleries, museums, and collectors are able to auction works from their collection in order to raise money for the purchase of future works, while keeping the art that has been sold in their collection. Although this is done through art-funds today, blockchain will greatly reduce the costs by eliminating the middlemen. For example, a gallery could raise funds to purchase a three-million-dollar artwork using a three-year art-secured loan at a 13.5 percent annual interest, or it could raise funds on a blockchain platform by auctioning some of their art using the model described above for a one-time fee that might be as low as 6 percent. This would represent a savings of over 400 thousand USD for the gallery.

25. This is great for the gallery and also for investors. Because the cost of transactions goes down dramatically, artworks valued at tens of millions of USD can be transformed into tiny digital units that can be easily bought and sold in real time: essentially a stock market for art.

## III. Challenge 3: Managing assets and digital rights

26. The multi-billion-dollar movie industry is also ready for disruption by innovative technologies like blockchain. This industry is currently highly-centralized, with the power residing in a few companies. In addition, movie production is often mired in legalese and fine print, which sometimes results in people not being adequately compensated for their work and/or not fully understanding the basis for their compensation.

27. There are three ways that blockchain technology could support improving this situation.

- Lowering the barriers for obtaining production financing by raising funds through blockchain platforms via the sale of tokens/coins and lowering distribution costs for the final product by using a blockchain platform for distribution;
- Improving transparency by receiving and spending funds using cryptocurrency and smart contracts, thus providing a trustworthy, and public, blockchain audit trail of how investors' funds were spent, and profits were distributed; and
- Improving the way digital rights are managed, through the use of smart contracts, in order to ensure that filmmakers, actors and other stakeholders, including those who have invested through token purchases are appropriately compensated.

## IV. Challenge 4: Enforcing intellectual property rights

28. Enforcing intellectual property rights (IPR) is an expensive and problematic issue for law enforcement and all holders of digital assets, including movie studios, music producers, distributors and artists. In this context there are the problems of piracy and forgery as well as the problem of content creators not receiving the royalty payments which should come to them.

29. This last issue is particularly complex in the case of movies which include a collection of copyrights and IPR, spanning across screenplays, derivative works from books, designs, technical works, licensing from other works, merchandise, actors' performances and so forth. In addition, there are many content creators who do not have enough clout (or enough

information) to enforce payment of the royalties they should receive because of their participation in the creation of a digital asset.

30. Blockchain distributed ledgers could help address these challenges by creating an immutable record of transactions involving any asset, idea or creative work, and also on the allocation of IPR across all parties involved. Thus, IPR could be tracked throughout the lifetime of an asset (or the copy of an asset), even when ownership is sold or otherwise transferred or assigned, including when these IPR assets are assigned to players in other industries, such as music, television, and the like.

31. There are a wide variety of blockchain initiatives in the arts. Many of these, even if it is not always their principal focus, support the enforcement of IPR as well as the reduction or elimination of piracy, the sale of forgeries and illegal copying. Some additional initiatives which have these objectives as their main focus are described below.

32. One start-up has launched an application that aims to keep track of, and identify illegal copies of digital assets like movies, music, eBooks and other media through blockchain technology and the use of an imperceptible watermarking technology. This watermark contains a Bitcoin reward that, if collected, notifies the holder of the IPR that their asset has been illegally copied.

33. Identifying the use of music is particularly complex because songs can be combined to form new compositions and mash-ups. To address this, one start-up has published a white paper on a solution based on digital watermarking for audio used together with a blockchain. This solution addresses problems related to licensing and royalty tracking as well as the provision of reliable and accurate indicators (data) for blockchains to act upon in support of IPR.

34. The problem with IPR enforcement is that it requires auditing, compliance checking and market surveillance. These requirements can be at least partially replaced by blockchain's ability to guarantee the trustworthiness of a transaction, before it takes place, including confirmation that the ownership of artwork and the identity of the artist(s) are accurate and remain unaltered. One blockchain initiative is focusing on this area by creating a convenient and effective way to trade art and track the history of artwork, thus minimizing counterfeit art, building trustworthiness within the art market, improving art trade services and increasing the economic and social benefits to the global art community.

35. There are also a wide range of initiatives in the area of blockchain and photography, which incorporate most of the features discussed above (watermarking, tracking ownership, creating IPR supportive marketplaces, etc.).

## D. Conclusion/Summary: Decentralization helps artists, producers and consumers

36. By now it should be clear that blockchain technology has the potential to disrupt, in a positive way, the business of art, especially in those sectors where intermediaries play a prominent role and/or there is a lack of transparency.

37. At the same time, for this potential to be realized, platforms and implementations need to be developed with good user interfaces and a critical mass of users. This will take time, but the incentives are there to create new paradigms, based on blockchain technology, that will result in a wider selection of choices in the arts for consumers as well as better livelihoods for artists.

## E. Further references

38. Other interesting links on this subject can be found below.

- https://www.forbes.com/sites/rogeraitken/2017/08/17/how-the-blockchain-is-disrupting-the-art-economy-as-we-know-it/#90020474fe76
- https://techcrunch.com/2016/10/08/how-blockchain-can-change-the-music-industry/
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# Section IX: Blockchain supporting the United Nations Sustainable Development Goals (SDGs)

## A. Introduction

1. In September 2015, 193 members of the United Nations endorsed 17 Sustainable Development Goals (SDGs) to be attained by 2030. The goals cover a broad range of social and economic development issues including poverty, hunger, health, education, gender equality, clean water, sanitation, energy, environment, and social justice and are accompanied by over 160 different measurable targets. They also emphasize the role that trade and innovation can play in support of sustainable development.

2. This chapter examines the possible contributions that blockchain technologies could make to the attainment of the SDGs.

3. The editors have looked at use-cases that were selected based on pre-defined criteria, as examples of possible good uses of blockchain technology to support the SDGs.

## B. Goal 1 - End poverty in all its forms everywhere

4. While global poverty rates have been cut by more than half since 2000, one in ten people in Low-Middle-Income Countries (LMCs) are living with their families on less than the international poverty line of 1.90 USD a day. More people however earn only slightly above this daily rate. In any case, poverty is more than the lack of income and resources to ensure a sustainable livelihood. Its manifestations range from hunger and malnutrition, to limited access to education as well as other basic services, social discrimination and exclusion, and lack of participation in decision-making processes.

5. Blockchain technology has great potential for use in various applications that would greatly aid in poverty reduction. Use cases demonstrate the practical use of blockchain alongside Internet of Things (IoT) and artificial intelligence technologies in order to provide a credible solution to food security (see Annex XVI). While eliminating hunger and malnutrition, this type of use case simultaneously creates avenues for the poor to generate income.

6. Poverty is a complex problem with many interlinked underlying causes. Below, we describe some areas where blockchain could be used to address these causes.

- **Identity**. Many poor people do not have birth certificates or official identities allowing them to go to school, participate in government programs or receive other benefits. Blockchains can be used to establish identity records using biometric data, voluntarily entered by individuals. Such a biometric digital identity can provide individuals with increased opportunities and governments with tools for reducing graft and better ensuring that benefits go to intended beneficiaries. Identities, which are recorded in a blockchain, are immutable and cannot be falsified.

- **Access to markets and finance**: In remote areas and communities small food producers usually have limited access to markets and to financing. Blockchain-based platforms can facilitate their access. Using a blockchain-enabled electronic commerce platform they could become visible and accessible to more markets, while the use of blockchain could allow them to arrange for payment directly, without intermediaries. Blockchain technology could also help them to establish reliable records showing their reputation as a vendor and their financial transactions. Because of the immutability of blockchain records, financial institutions may be willing to use this

information as a form of credit rating thus opening new opportunities for trade financing. Identities established on a blockchain network for individuals (for example, rural poor rarely trade as anything else) also have the potential for improving access to financial services (i.e., bank accounts, loans and insurance). These facilities could decrease the costs of rural producers and enable them to reinvest more money into their local businesses.

7. Blockchain networks can be used to deploy IoT devices such as drones to collect data in a timely and cost-efficient manner. This network can be used especially when automating tasks that are otherwise expensive and labour intensive. The protocol allows multiple stakeholders to benefit, including:

- Drone and drone charging station owners;
- Developers rewarded in tokens for building machine-learning-applications for the network; and
- Businesses and communities that employ the protocol to enhance their operations and reduce their costs.

8. As an example, a farmer could deploy renewable energy charging stations for drones to autonomously recharge their batteries and continue their tasks. When a charging station is utilized, the device's owner is then rewarded with tokens. Further, farmers who permit data collection on their property, can sell this data to businesses such as commodity traders that are trying to gain insights on harvest estimations (see Annex XVI).

9. Blockchain application with the potential to reduce poverty can use biometrics to overcome the weakest link in the blockchain: the cryptographic private key. The platform can certify that a private key cannot be lost, stolen, forged, copied or forgotten. This has important potential for the large-scale humanitarian deployments of blockchain payments. This could eliminate the majority of fraudulent transactions as well as misappropriation of funds, therefore stretching donor funds further. This use case can greatly strengthen Know Your Client (KYC) procedures by making available cost-effective identification tools for use by those organizations best equipped to improve the financial inclusion of previously marginalized people with no access to formal banking services (see Annex XII).

10. Additionally, a blockchain can automatically records transaction on a secure ledger with instantaneous financial settlement. This means there are shorter payment cycles in comparison to traditional banking and third-party payment methods. Such efficiencies could be harnessed to help eradicate poverty, as they promote more transparent and equitable trade which, in turn, helps to ensure that all men and women – particularly the poor and vulnerable – have equal rights to economic resources.

11. Using blockchain, the authorization and settlement of point of sale (POS) transactions can be made outside of the traditional banking system, therefore eliminating transaction fees which are usually 1.75 percent. Furthermore, beneficiaries of support programs who have no access to the banking system can be provided with dignified financial inclusion, allowing them to feed their families by using only their iris to securely authenticate their identity and authorize a retail transaction. On the other hand, donors are also reinvigorated in the knowledge that such a blockchain platform ensures the accuracy of transactions, with only the intended beneficiary able to use the funds. Therefore, fraudulent transactions to ghost recipients which are often an unfortunate consequence of card or voucher-based aid distribution are eliminated.

12. Finally, another potentially powerful use-case which governments can use to increase citizen participation in the economy is the issuance of mobile retail bonds that can be accessible to a vast majority of its population who have access to basic feature phones (see Annex XVII). In this way, government are able to redirect interest that would have been paid

to commercial banks and other institutional investors to its citizens and their needs. This allows the government to gather resources for economic development through the use of mobile phones. The use of proceeds can be infrastructure development and, as such, the interest could be tax-free, hence giving a decent return to the investors.

13. The most beneficial feature of would be the creation of a pathway for citizens to improve their financial well-being. Such bonds could allow citizen investors to save and invest towards their future by having their money work for them. The uniqueness of M-Akiba is in its simplicity. The technology used eliminates the complex elements of a typical bond and sells them to citizens as a loan to the government which then pays interest to bond purchasers that is payable every six months. In addition, the platform's ability to offer access to the bond through basic phone features highlights its level of convenience. Furthermore, the return it offers as government paper is guaranteed and fixed for the life of the bond. The savings made by purchasing bonds can be used for a family's future development agendas. In the event that the money invested in bonds is needed, the customer can sell the bond in the secondary market. This is because of the availability of a guaranteed buyer in the form of one or more liquidity providers and rules which allow the customer to receive the accrued interest without penalties up to the time of sale.

14. Blockchain is useful because the bonds can be represented as digital assets in immutable distributed ledger records and, then, through smart contracts, the bond coupons (i.e., interest) and total amount are paid with no human intervention. This significantly lowers the cost of servicing a large number of small bond holders, thus making this project financially feasible.

15. There is an opportunity for enhanced accountability in the use of block technology to track the use of proceeds. Such a platform can thus be a win-win model for the government to get necessary funds for development while also championing financial inclusion and encouraging a culture of saving and investing for the benefit of future generations. Such bonds purchased using mobile phones could also be used by savings groups as an alternative to rotating funds that do not generate interest.

## C. Goal 2 - End hunger, achieve food security and improved nutrition and promote sustainable agriculture

16. The SDGs aim to end all forms of hunger and malnutrition by 2030, making sure all people (and especially children) have access to sufficient and nutritious food all year round. This involves promoting sustainable agricultural practices which support small scale farmers as well as creating equal access to land, technology and markets. International cooperation is also required in order to ensure investment in infrastructure and technology for the purpose of improving agricultural productivity.

17. Blockchain technology as decentralized/distributed technology can contribute substantially to the realization of the SDG 2 target of "Zero Hunger by 2030". Because blockchain technology enables commodities, such as food, to be traced from its origin to its destination, it can be useful.

18. In addition, the introduction of blockchain technology can also contribute to more sustainable food production. This could strengthen the supply side and particularly small-scale food producers and family farmers, thus enabling them to better access markets and receive equal treatment in the supply chain.

## D. Goal 3 - Ensure healthy lives and promote well-being for all at all ages

19. Non-communicable diseases and mental health have been attracting new attention and funding; competing with the traditional focus on infectious diseases such as HIV, TB and Malaria. As a result, priority is being given to the strengthening of health systems as well as finding new ways to overcome brain drain and shortages in the health workforce, with eHealth establishing new directions in health promotion and information. Impressive advancements have been made on many healthcare fronts including new treatments, pharma access programs and stakeholders' impact donations. However, to meet the SDG health targets, progress must be accelerated especially in regions with the highest burden of disease.

20. In the context of trade facilitation, blockchain applications create significant new opportunities globally. Blockchain technology-based applications can incentivize patients and populations at risk to trade personal data for a fee, thus opening up a new market while also advancing medical research. Current electronic medical record (EMRs) systems lack a standard data management and sharing policy. This makes it difficult for pharmaceutical scientists to develop precise medicines based on data obtained under different policies. In this regard, blockchain-based information management systems could enhance the exchange and trade of health-related data while ensuring patient privacy.

21. The use of blockchain to improve traceability in the drug supply chain opens-up another important support for SDG-3, by enabling better anti-counterfeit measures (e.g. serialization of pharmaceutical goods) up to the level of individual pills. Counterfeit pharmaceuticals present a serious health risk, especially in developing countries where this problem is more wide-spread. Applications, based on blockchain, and providing consumers with easy access to information about the valid identity of a drug can both improve the accuracy and handling of goods, and reduce health risks from counterfeit pharmaceuticals at an affordable cost.

22. Blockchain technology could also support prevention and treatment through smart contracting and tokenization. Improved health outcomes could be greatly enhanced through health-promoting tokens, which are paid out in order to incentivize health promoting behavior at individual, national and even regional levels. Such smart contracts could advance the attainment of specific SDG targets (e.g. "By 2020, halve the number of global deaths and injuries from road traffic accidents") and reduce behaviors that result in poor health outcomes, based upon financing from donor funding and national/regional health authorities.

23. For example, potential solutions that utilize distributed ledger technology with embedded artificial intelligence to drive transparency and accountability in economic development activities. This infusion of technology into human-driven processes is anticipated to incentivize behavioral change and improve the rate of project execution across various segments of the value chain. Such solutions can facilitate secure collaboration between sustainability & tokenization best practice solutions, hoping to impact projects' execution and result in fast track funding.

## E. Goal 4 - Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all

24. Obtaining a quality education is the foundation to creating sustainable development. In addition to improving quality of life, access to inclusive education can help equip local people with the tools required to develop innovative solutions to their greatest problems. The reasons for a lack of quality education include: a lack of adequately trained teachers, schools in poor conditions and equity issues related to opportunities provided to rural children. In order to provide quality education to impoverished families, it is necessary to invest in

educational scholarships, teacher-training workshops, school building and improved water and electricity access for schools.

25. Improving access to educational resources is a priority for many major international NGOs. To attain this, better tools and more cost-effective means of delivering educational content are required. At present, there are few tools which are tailored to track educational achievements in distressed environments where content delivery is irregular. In this regard, blockchain technology could provide a robust framework for monitoring educational programs and securely managing student credentials.

26. Blockchain-based platforms could connect students, educators, and service providers where, together, they develop and engage in personal and group, in-person educational programs (see annex XIV).

27. Using encryption technologies within the blockchain, the solution could shield end-user identities from bad actors, while at the same time empowering members of displaced populations by providing them with self-sovereign education credentials that they can share with potential employers in order to become fully employed. Such a solution can also provide digital wallet that can easily be used to gain access to digital tokens and currencies. Blockchain technology can also provide a system for victims of involuntary migration to reclaim their already-earned credentials, thus regaining dignity, and respect and accelerating their community's economic recovery.

28. Other benefits and possible uses of blockchain in education include:

- The collection of funds and the giving of donations to needy students as well as tracking the use of funds from donors and boards that provide higher education loans;
- Loyalty cards in learning centers which can be used for student meals; or
- In content development and books where authors and publishers could not only secure their intellectual property but also benefit directly and at a larger scale from direct sales.

## F. Goal 5 - Achieve gender equality and empower all women and girls

29. This SDG's aim to ensure that there is an end to discrimination against women and girls globally. There are still huge inequalities in the labor market in some regions, with women systematically denied equal access to jobs. Sexual violence and exploitation, the unequal division of unpaid care and domestic work, and discrimination in public office, all remain huge barriers.

30. Social value propositions, which support the achievement of gender equality and women's empowerment can, in a number of cases, be more easily developed with blockchain technology. For example:

- Blockchain smart contracts use only the data defined in their code for making decisions, and if this does not include data that is sex biased (such as the sex of the participant, current income which may be greater for men, or years of work experience which may often be less for mothers), then the results will not discriminate against women.
- In addition, blockchain applications that are on public blockchains, or provide open public access, remove the need for intermediaries and help to ensure that the benefits from these applications are equally available to both men and women. While the same can be said, generally, for other Internet-based services, the key advantage provided by blockchain applications is that they can include the transfer of

economic value in the form of crypto-currencies, trustworthy certificates or other blockchain-notarized data of economic value.

- Blockchain based proofs of education such as original records of skill and knowledge certificates obtained could provide women with the opportunity to increase their participation in the job market and in leadership roles. This could be in economic, political and social spheres. Access to certifiable knowledge empowers women and could be made possible through a number of channels, including blockchain based open-access platforms. Such platforms, would also empower women by providing them with, overall, greater access to knowledge

- Some blockchain applications help users to control their on-line identities and the personal data that is available to others, even allowing users to charge for their data. This could help women earn additional income and avoid on-line harassment. Other blockchain applications support trustworthy online voting, which can help women to participate on a more equal basis in society.

31. Equal access to enabling technologies, information and communication technologies, together with other basic requirements (i.e., health, education, employability, etc.), can provide more equal opportunities for women, girls and other disadvantaged groups. The above blockchain-based applications, together with those that help to reduce poverty (women being disproportionately represented among the poor) and improve health (women having a disproportionately large role as care givers), show that blockchain technology has the potential to make a very significant contribution toward improving the lives of women, empowering them and supporting gender equality.

## G. Goal 6 Ensure availability and sustainable management of water and sanitation for all

32. Clean water is an essential resource for life, yet its unbalanced distribution globally has caused wars, as well as instability and disproportionately elevated levels of disease and morbidity. Blockchain-based technology could help to improve this situation by fundamentally transforming the way water resources are managed and traded.

33. Every day, more than 180,000 people, primarily in emerging markets, move from rural to urban settings, creating mega-cities where large-scale, centralized water infrastructures may not be feasible due to financial constraints, governance challenges or climate variability. At the same time, water basins throughout the world are facing increasing stress caused by climate viability, population growth, industrial use and other drivers of water scarcity. Expanding access to safe water and sanitation are a pressing challenge which effects many of the other SDGs.

34. With only a small fraction of the earth's water readily available for human consumption, innovations in developing new sources of supply are an important part of any set of solutions for addressing water shortages. The same can be said for sanitation, with target two of goal 6 aiming to achieve access to adequate and equitable sanitation and hygiene for all as well as to end open defecation. This needs to be done with particular attention paid to the needs of women and girls and those in vulnerable situations.

35. Blockchain technology could make significant contributions to the attainment of water and sanitation targets in several ways:

- Harnessing blockchain could enable households, industries, water managers and policymakers to all access the same data on water quality and quantity in order to make more informed decisions. This could be done by combining a protocol and decentralized network that could be used to deploy IoT devices such as drones (see annex XVI). This can be used to collect data on water resource distribution

and sanitation in both a timely and cost-efficient manner, with particular regard to automating tasks that are otherwise expensive and labour intensive.

- Blockchain technology could also support peer-to-peer trading of water rights in a given basin. This would empower water users with enough supply or with the capacity to share excess resources to do so 24/7, and without relying on a centralized authority.
- Efforts to integrate blockchain technology and IoT into toilet networks in high priority areas can also generate valuable data and information on public health and consumer behavior, as well as the quality of maintenance systems and how to optimize routes for waste collection and transportation.

36. Whether through their role in retrofitting cities to become more resilient, or through data provided to support better design of basic service delivery systems to meet the needs of expanding urban areas, blockchain technologies are generating new insights as well as economic opportunities for improved water management and sanitation.

## H. Goal 7 - Ensure access to affordable, reliable, sustainable and modern energy for all

37. SDG 7 on “Affordable and Clean Energy”, concerns ensuring the availability of modern energy for all. For example, increasing the share of renewable energy and doubling the efficiency of energy production. Enhancing international cooperation in order to facilitate access, research, and development of both technology and its supporting infrastructure can achieve this.

38. Many aspects of the energy industry are going through major changes. On one hand, new technologies are constantly developing and emerging and, on the other hand, regulations such as those dealing with reducing climate change effects have major ramifications [see SDG 13]. Blockchain, through its features, is expected to directly impact the structure of energy markets, especially grid-flexibility, trade, regulations, and public scrutiny.

39. Blockchain’s automated transactions are carried out by smart contracts which are agreements embedded in code, running on a blockchain. These agreements make it possible to set, in advance, the conditions for automatic transactions to take place between energy clients, businesses, and energy-consuming machines which are connected to the grid. However, not only can smart contract automation reduce administrative costs, more importantly, it can also enable more efficient allocation of electricity within the grid.

40. In addition, a digital ledger enables the monetization of the micro-consumption and generation of energy. Due to blockchain’s ability to validate transactions, low-value consumption, and low-value generation of electricity is no longer disincentivized because of transaction fees.

41. The ability to have energy-billing micro-transactions can change the way energy is priced, consumed, and billed. On a local scale, the combination of blockchain, micro-consumption, and micro-transactions gave birth to micro-grids: these consist of an independent community of small stations producing renewable energy and those who consume it, that balances and manages energy uses and pricing. By connecting micro-grids, it is also possible to effectively impact and interact with the traditional energy grid. Even if the production of renewable energy is done in remote territories, small stations and remote communities, these can be connected to the traditional energy grid on-demand for the sale of excess energy, thus gradually increasing renewable energy production. Such a change in energy market structures could create an opportunity to develop the energy market ecosystem in developing countries. This kind of network of micro- and traditional-energy markets holds great potential for developing countries, as it can promote investment and expand the energy

infrastructure. Blockchain can support this happening by providing a minimum-cost framework for managing the accounting and billing functions like with the micro-consumption and micro-generation of electricity.

42. Blockchain, if used for accounting across a national energy grid, can also create transparency in countries' emissions which can be used to promote public scrutiny of consumption and to demonstrate improvement.

43. Reliable consumer energy infrastructure can increase access to usage. The widespread implementation of small stations producing renewable energy, even if located in remote areas, can be easily linked with the traditional energy grid and, thus, can gradually increase the share of renewables in energy production. Such a change to the energy market can result in an opportunity to develop the energy market ecosystem in developing countries. The energy market holds great potential for developing countries, as it can promote investment and expand energy infrastructure. Creating blockchain technology platforms for renewable energy producers and consumers can enable the direct transfer of electricity, as a function of demand and especially with distant or remote locations. Blockchain technology, through smart contracts that can manage complex accounting transactions, can also enable the transfer of energy across interoperable platforms adoptable by different supply systems.

44. More details and specific examples of the use of blockchain technology in energy and trade in energy can be found in the energy section of this White Paper.

## I. Goal 8 - Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all

45. Roughly half the world's population still survives on an equivalent of about 2 USD a day. Considering the global unemployment rate of 5.6 percent, having a job doesn't guarantee an escape from poverty in many places. This slow and uneven progress requires that economic and social policies aimed at eradicating poverty be rethought and reworked.

46. Sustainable economic growth will require societies to create conditions that allow for quality jobs as well as decent, environmentally friendly and sustainable working conditions that stimulate the economy. In order to accomplish this, there needs to be increased access to financial services to manage incomes, accumulate assets and make productive investments. A rise in commitments to trade, banking and agricultural infrastructure will cause an increase in productivity and a reduction in unemployment levels in the world's most impoverished regions.

47. Among the identified problems to be solved in order to reach these goals are a number of financial objectives two of which could be summarized as: 1) government access to domestic financing at a reasonable cost and 2) access to interest bearing savings instruments for the poor and emerging middle class – more the emerging middle class because a 30 USD investment may sound like a poor person's investment to some, but the really poor have no money to invest at all.

48. Blockchain can help address these two issues by making it cost effective to sell small parts of bonds and make payments designed for the needs of the poor and track all of the related information.

49. blockchain can allow the sale of small value mobile retail bonds, promotes inclusive growth in an economy by democratizing sovereign debt (see Annex XVII). In many developing countries, relying on foreign aid may not be sustainable in the long run. However, if a greater portion of the government's expenditures can be obtained from its citizens, this can help circulate the funds that are necessary to grow the economy within that country.

50. The proceeds from such mobile retail bonds can be used to develop core infrastructure in a country. Such investments could then create indirect benefits that would spur development through improved transport infrastructure, ease of doing business, and increased trade in goods. This would, in turn, result in more employment opportunities.

51. Millions of people across the globe and especially in the emerging world live in extremely sub-optimal conditions. This is sometimes made worse due to friction and lack of transparency at various levels of development project execution. Abandoned projects due to mismanaged funds and/or outright theft, leave affected populations, and especially the most vulnerable, worse off each year. The question in this regard is, what if a solution existed to track these projects from funding to project execution using local people as monitors and custodians of their own economic development?

52. A blockchain solution can incentivize behavioral change across various segments of the value chain and improve the rate of project execution. This can be done while minimizing waste and, as a result, activating economic development and inclusion for those left behind.

## J. Goal 9 - Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation

53. The 9th sustainable development goal is also closely related to economic development. Blockchain's novel properties such as immutability of transactions and transparency of records, can be used in a wide variety of applications, and, in particular as a source of innovation in processes, is expected to highly influence the advancement of this goal.

54. Local initiatives have created blockchain-based projects that have already advanced the resilience of regional infrastructure local economic development. (see Annex XVII)

55. Other initiatives are intended to have impact at a global level. For example, crypto-currencies which are regulatory compliant are expected to offer new financial frameworks for trade between and within countries. One such concept is that of stable coin cryptocurrencies, which are intended to provide currencies which can act as a safe store of value for all regardless of the owners' nationality or location. this could be linked to the value of the International Monetary Fund's unit of accounting called an SDR. Unlike most other blockchain cryptocurrencies, this can be combined with full "know your customer" processes for all coin holders which can be an attractive feature for governments and regulatory authorities. (see Annex XV)

56. Stable coins typically look to control their price volatility based upon rules that are known in advance, embedded in code, and transparent for all to see. When human discretion is required, decisions are taken by holders of the currency according to rules laid out in the currency's governance policy. This is an important feature, especially for commercial activities in economically devastated areas with diminished currencies. It opens up possibilities for offering marginalized populations a true alternative for storing value. For example, stable coin crypto currencies could be used to pay salaries when local currency cannot keep its value.

57. Trading with a blockchain-based regulatory-compliant global currency, can enable micro-transactions which are an important enabler of services and particularly services tailored for the poor. Reducing the costs of transactions, also has the potential to free up more funds for use by the poor, or in the case of development aid, more funds to support the poor. It offers secure mobilization of funds, since all records are transparent and open to public and international audit. This can help ensure that the receivers of funds are more accountable for how funds are spent.

58. By offering equitable blockchain platforms which can be accessed by anyone connected to the Internet, individuals and small-scale enterprises can have the ability to perform micro-transactions and use other financial services which were previously too expensive – blockchain being able to dramatically reduce the cost of offering them. The possibilities offered by blockchain have resulted in a surge in innovation across a range of fields and this is expected to result in new services for the poor, and also, eventually, in increased employment .

59. Accessible blockchain-based financial tools have the potential to open new markets and expand the horizons of existing ones. The availability of reliable, low-cost blockchain fund transfers also have the potential to support the upgrading of industrial sectors through, for example, increasing access to information and communications technologies, research, as well as the adoption of clean energy technologies.

## K. Goal 10 - Reduce inequality within and among countries

60. The challenging task of reducing inequalities in the economy, governance, rights and decision making is imbedded in the specific targets of Goal 10.

61. One example is "Encouraging official development assistance and financial flows, including foreign direct investment, to States where the need is greatest and, in particular, for least developed countries, African countries, small island developing states and landlocked developing countries in accordance with their national plans and programs." As a result, this SDG, in line with a number of others mentioned earlier, also faces the challenge of donor countries' funding reaching the right recipients in the prescribed amounts and on time.

62. Blockchain technology could also support better economic equality by reducing the costs of remittances. Today, the benefits of remittances from international migrant workers are reduced by the generally high cost of transfer. On average the charge for sending 200 USD – the benchmark used by authorities to evaluate cost is 14 USD. The use of blockchain technology could result in significantly lower transfer fees than those reflected above and thus support greater equality in economic opportunity for the poor.

## L. Goal 11 - Make cities and human settlements inclusive, safe, resilient and sustainable

63. Cities are hubs for ideas, commerce, culture, science, productivity, social development and much more. At their best, cities have enabled people to advance socially and economically. It is estimated that two thirds of the world's population will be living in cities by 2050 (2.5 billion more than today) and by 2030 the world is expected to have 43 megacities with more than 10 million inhabitants, compared with 31 today. Therefore, it is important that efficient urban planning and management practices are in place to deal with the challenges brought by urbanization.

64. Many challenges exist with regard to maintaining cities in a sustainable, environmentally friendly manner that is cognizant of job creation, prosperity and resource preservation. Common urban and rapid urbanization challenges include congestion, lack of funds to provide basic services, a shortage of adequate housing, declining infrastructure, poor sanitation and rising environmental pollution within cities.

65. It is important that cities in the future provide opportunities for all, with access to basic services, energy, housing, transportation - and in a sustainable way. Block chain can help to support this objective. When combined with Internet of Things (IoT) sensors, blockchain smart contracts could be used to reduce the cost and increase the efficiency of some services such as parking and shared vehicles. To support access to urban services, while

reducing fraud, blockchain-based ID platforms can allow citizens to be identified undertake transactions based on their biometric identity without the fear of losing their digital wallets or forgetting passwords. (see Annex XII)

66. Blockchain can also support, in a cost effective and trustworthy manner local democracy within cities, allowing neighborhoods and large housing developments, to have a voice, through voting, on decisions that affect them. An example of such a system has been implemented in Moscow and there are plans for other local voting using blockchain in Seoul and Vienna .

67. Land registration is a blockchain application being implemented in a range of countries and urban areas including Georgia, Ghana, Sweden and Ukraine. The city of Seoul, Korea launched 14 blockchain projects in October 2018, including for the registration of 29 civil certificates, a system to create trust in used car sales and the automatic payment of part-time workers and sub-contractors. All of these applications have as objective making the life of citizens easier and many of them should also result in reduced fraud.

68. Citizens could also choose whom to share their personal data with, and through such platforms subsequently earn money in the process. This could be based on a protocol and a distributed application (dApp) that guards personal data, provides safe storage and enables provable personal data exchange. Information can be shared anonymously or on a need-to-know basis based on an agreement between exchanging parties. Because privacy is a human right the processing of personal data is being increasingly subjected to very strict privacy protection regulations globally. A decentralized solution can put the individual in control of their data, while simultaneously allowing for a censorship-proof exchange of data without intermediaries. (see Annex XIII)

69. Traffic congestion could also be monitored in smart cities through blockchain powered drones. (see Annex XVI)

70. This technology can be combined with consensus algorithms in order to keep all the positive characteristics of Blockchain technology (data records and storage) while increasing throughput to more than 200,000 transactions per second. (see Annex XVIII) This network can be used as a proof-of-stake consensus method, which eliminates the need for massive energy consumption and thus reduces environmental pollution. Such a block chain solution is particularly relevant for applications with larger volumes of transactions, such as those which may be used on a daily basis in large urban areas and, like other blockchains, could also be used to raise funds (i.e., via -Initial Coin Offerings or ICOs) for various development projects within a particular city.

## M. Goal 12 - Ensure sustainable consumption and production patterns

71. SDG 12 aims to promote more responsible consumption choices and production patterns. Important areas to address include sustainable business practices and consumer awareness and behavior. In order to move in this direction, transparency and visibility of value chains and production processes are key steps for gaining a better understanding of social, environmental and health risks and ensuring due diligence.

72. Probably the most advanced application of blockchain technology, outside of its use for cryptocurrencies, is in the area of tracking and tracing goods. There are a large number of private enterprises who are implementing and/or testing the use of blockchain technology in order to achieve greater transparency and visibility in their supply chains and production processes.

73. One example of such a project is the development of a blockchain proof-of-concept application in cotton and leather supply chains. This aims to support due diligence and compliance processes, by moving all existing transactions onto a permissioned blockchain,

thus guaranteeing access to secure information by all partners. It could also provide the consumer with trusted and validated information about the origins of the cotton and leather products they purchase.

74. The tracking and tracing of food in supply chains relates closely to consumers' awareness of the origins of products, sustainable production methods and food health implications. SDG 12.8, for instance, specifically aims to ensure access to relevant information and awareness of sustainable development and lifestyles for all. (see Annex XVIII)

75. Tracking and tracing applications can also support anti-fraud initiatives for food products. Fraud in the food supply chain is an important challenge because of the potential health risks related to the manipulation of food supplies. Food fraud also undermines customer confidence and is one of the biggest issues currently facing the global food industry.

76. More details and specific examples of the use of blockchain technology for tracking and tracing can be found in the agriculture and supply chain sections of this White Paper.

## N. Goal 13 - Take urgent action to combat climate change and its impacts

77. SDG 13 focuses on urgent actions to combat climate change and its impacts. In a world of constant population growth, continued high energy use in developed countries and the rapid industrialization of developing countries, we see rising resource consumption and increased energy demand which pose challenges to the ability of the world to meet climate change goals, and create the risk of irreversible ecological disaster. Blockchain technology could be used to create more collective involvement and, its unique features can also offer novel solutions to fighting climate change.

78. Natural disasters are frequently linked to climate change. In these situations, aid is needed both for rescue operations and for restoration. Blockchain support for supply chains has promise for facilitating the movement of humanitarian relief in such scenarios. For example, blockchain smart contracts could be used to swiftly allocate resources across the range of disaster relief organizations active in the affected region and track the related supplies such as clean water, medication, food, and other goods, as they move to the disaster location and are delivered..

79. Blockchain also holds great promise as a technology that could impact the combat against climate change by:

- Creating greater involvement;
- Building new financial ecosystems; and
- Providing technological platforms for trading clean energy and a marketplace for greenhouse gas emissions trade and reduction.

These three may sometimes overlap, but are described, separately, below.

80. The involvement of individuals, states, and corporations can be increased through greater transparency and efficiency. Blockchain could be used for tracking and tracing the carbon footprint of goods and energy use in public buildings – for example. The transparency of these records in a blockchain could leads to better accountability because of their openness for public scrutiny.

81. The development of new financial ecosystems are on the rise to finance research, technological development, and the implementation of blockchain technology to tackle climate change. These opportunities include a change in the financing of climate-related technologies. New blockchain-based ways to mobilize funds ensure that capital arrives at the intended recipient and is used as agreed as well as being open for public audit. There is,

therefore, a possibility for new leading research on innovative climate technologies which can then be cultivated in accelerators and incubators, leading to the formation of partnerships and capital investments.

82. Novel platforms for clean energy trade and greenhouse gas emission monitoring also hold great promise for combating climate change. Smart contracts will, potentially, enable a more efficient allocation of electricity [see SDG 7]. Blockchain technology can also be implemented to support the development of carbon marketplaces. While traditional technologies are subject to accounting flaws and fraud – which have held back the development of such marketplaces in the past, blockchain platforms for trading assets which represent carbon could guarantee immutability and transparency.

83. For example, under the Paris Agreement of the United Nations Framework Convention on Climate Change, developed countries are able to lower the costs of meeting their nationally determined contributions by financing cheaper emission reductions in other countries. Thus, contracts between developed and developing countries can mitigate climate change carbon impact while also supporting the development of more sustainable economies in developing countries. Internationally Transferred Mitigation Outcomes [ITMO] can be traded as the unit of value for carbon impact. Blockchain's unique features such as minting unique non-fungible digital trade units, make it possible to "mark" each unit with relevant information about its creation, national approval, and other relevant details. Blockchain information is reliable and accessible, and also immutable. As such, it can remove barriers for efficient carbon trade, and raise the accountability of those who are in charge of the future.

## O. Goal 14 - Conserve and sustainably use the oceans, seas and marine resources for sustainable development

84. The SDGs aim to sustainably manage and protect marine and coastal ecosystems from pollution, as well as address the impacts of ocean acidification and other negative practices such as over-fishing. Enhancing conservation and the sustainable use of ocean-based resources through international law will also help mitigate some of the challenges facing oceans.

85. Blockchain technology can be an important tool for implementing a circular economy, which is one of the main elements required for the conservation and sustainable use of aquatic resources. One of the main reasons of pollution is the focus of existing industry on end products for markets, with little attention paid to the entire product life cycle, or the use of recycled materials and the extremely slow implementation of circular business models. The tracking of fishing practices and products from origin to market, together with the inclusion of scientific cooperation to minimize negative impacts at all stages of the supply chain, is now possible with blockchain technology. An example of such a project is currently being implemented by the World Wildlife Foundation in Australia in order to reduce illegal fishing.

86. Minimizing ocean acidification, through access to data on the main polluters' business processes, could contribute to better management of data and better decision-making on the resources used in production processes. Therefore, this could contribute to the sustainable management of fisheries, agriculture and tourism.

## Q. Goal 15 - Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss

87. The annual net loss of forest area globally from 2010 to 2015, was less than half of that recorded in the 1990s. However, the proportion of land area covered by the forest

decreased from 31.6 percent in 1990 to 30.8 percent in 2010, and held constant at 30.6 percent in 2015 and 2016. Average worldwide coverage of terrestrial, freshwater and mountain key biodiversity areas is still below 50 percent. From 1998 to 2013, about one fifth of the Earth’s land surface covered by vegetation showed persistent and declining trends in productivity. Reversing the effects of land degradation and desertification through sustainable land management is therefore key to improving the lives and livelihoods of more than one billion people currently under threat. These are several of the challenges under this goal, which blockchain technology may help to address effectively.

88. As one example, blockchain technology could be used to incentivize organizations and individuals to increase the scale and efficiency of conservation protection by offering small cash payments in exchange for conserving nature. Quick verification of the conservation contract, getting the cash to distant communities and cutting transaction costs are all features that can be implemented with blockchain technology.

89. To halt biodiversity loss, tracking of trade endangered or rare species is essential. In this case, blockchain technology could certify the exact origin of such products by tracking each stage of its supply chain.

## R. Goal 16 - Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels

90. SDG Goal 16 is entitled "Peace, justice and strong institutions" and outlines the aims for sustaining peace, security and prosperity. Strengthening the rule of law is the fundamental key for succes in this process of achieving peace. In this regard, trade and commerce are important elements for strengthening the rule of law. Blockchain applications can have a high impact on this SDG in those areas.

91. Key features of blockchain projects include the transparency of the digital ledger, and the accessibility of funds to support the transactions of parties at all levels e.g. transactions of individuals, domestic commerce, and international trade. In order to use both features, blockchain project users must be identifiable. This can be a challenge in countries where many people lack legal identity, there is human trafficking, or some parties are excluded from financial services.

92. Identification may be a challenge for two main reasons. first, a great deal of the population is not registered by the authorities. Second, on a technical level, is the question of how the registration of citizens can be accelerated. A few projects are working toward advancing the identification of individuals. (see Annex XII) this can be done biometrically authenticating individuals using technology Biometry can also be combined with artificial intelligence (AI) in order to enable blockchain-based efficient identify verification. With regard to privacy concerns, blockchain platforms can also allow individuals the ability to set permissions down to a key-value pair, under GDPR -compliant encrypted storage. (see Annex XIII)

93. Identification of citizens is, in itself, a sub-goal of this SDG. In the blockchain context, it enables the feature of transparency in transactions, and the immutability of asset registration. By adhering to KYC procedures, it is possible to be compliant to various financial regulations, such as anti money laundering.

94. The development of “effective, accountable and inclusive institutions” is supported by the immutability and transparency of information registered on a blockchain which can assure that government decisions and documents, as well as other relevant data, are accessible to the public and available for criticism, for better strategy-making incorporations and to governments in order to optimize their work and better ensure standardization.

95. The features of transparency, immutability and compliance with regulations which can be built into smart contracts, render the mobilization of funds through blockchain projects easier to audit than traditional methods. This function appeals to charity projects as well which can offer ecosystems for charity programs to tokenize fund raising campaigns, both aiming to build upon these blockchain features in order to advance donations for projects toward implementing all of the SDGs, including peace.

96. Peace is also supported by reducing poverty and economic development, so the reader should also refer to the information for SDGs 1 and 8.

97. Whether for charity or commerce, receivers of funds through a blockchain can be held much more accountable to investors. Investors are assured that digital assets and funds arrive at the desired destination, thus preventing misallocation of funds. Transparency and compliance can prevent money circulating in black markets, hence eliminating illegal activities such as terrorism, corruption and bribery; or, alternatively, promoting tax collection, standardization of international trading systems, and the overall enforcement of the rule of law.

## S. Goal 17 - Strengthen the means of implementation and revitalize the global partnership for sustainable development

98. The world today is more interconnected than ever before. Improving access to technology and knowledge is an important way to share ideas and foster innovation. Coordinating policies to help developing countries manage their debt, as well as promoting investment for the least developed, is vital to achieving sustainable growth and development.

99. This goal’s aim is to enhance North-South and South-South cooperation by supporting national plans to achieve all the targets. Promoting international trade, and helping developing countries increase their exports, is all part of achieving a universal rules-based and equitable trading system, that is not only fair and open, but also is of benefit to all.

100. Strengthening domestic resource mobilization and improving domestic capacity for tax and other revenue collection can be achieved through platforms based on distributed ledger technologies/blockchain technology. In addition, the efficiency of tax collection using blockchain-based platforms is much higher, taking into account the transparency, traceability and immutability provided by blockchain. Introducing interoperability on the regional and international level can also have positive effects on national economies as it decreases the possibility of fraud, illegal transfers or tax evasion and minimizes the effect of these negative externalities.

101. Blockchain-based platforms support different types of partnerships and collaboration between governments, companies, academia, civil society and individuals where trustworthy information and value transfers are needed. Bridging the digital divide and increasing digital literacy with enhanced use of blockchain technology can support the empowerment and capacity building of communities, regions and on the international level. As described often within this paper, blockchain applications can also strengthen the decision power and democratic decision-making processes of included groups and individuals.

# Annex I: IPCSA initiative

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| Section / Sector | Section III: Maritime Trade |
| Short description | A blockchain based digital bill of lading will be an additional service that the International Port Community Systems Association (IPCSA) members will offer to its community to complete the digital coverage that they offer today to the maritime trade business process. |
| Proposing / Implementing / Testing Organization | International Port Community Systems Association (IPCSA). |
| Contact for further information | richard.morton@ipcsa.international<br>GADIBM@israports.co.il |
| Long description | PCSs are constantly seeking to promote a more secured and efficient maritime trade process as well as a better service to the members of the community.<br>IPCSA members offer today digital solutions for the majority of the processes in the maritime community.<br>One of the most important documents in the maritime trade process is the Bill of Lading (BoL), and it is still a physical document.<br>A BoL is a negotiable document issued by a carrier (or his agent) to acknowledge receipt of cargo for shipment.<br>BoL are one of three crucial documents used in international trade to ensure that exporters receive payment and importers receive the merchandise.<br>There are a number of direct players in the BoL process:<br>in the exporting country: Exporter, Exporter's customs agent, Exporter's shipping agent, Advising bank<br>As well as in the importing country: Importer, Importer's customs agent, Importer's shipping agent, Issuing bank<br>The IPCSA Blockchain based Digital BoL service will allow all those business process players to issue, approve and endorse the BoL.<br>PCSs added value to Blockchain based Digital BoL process:<br>1. Existing trusted networks for process harmonization and integration.<br>2. Adding real time port processes information to reduce risk<br>3. Bridging different technology adoption levels<br>4. Gateway for local and global network<br>5. Gateway to government authorities |
| Description of potential business benefits from blockchain use | Lower probability for frauds that leads to reduces business risk.<br>Using real Port data (through PCS) like arrival/departure time, reduces risk by receiving online first hand information.<br>Reduce handling time and costs.<br>Reduce storage costs.<br>Better service for the customers. |
| Special concerns (legal, technical, etc.) | When looking to transform a maritime trade business process using blockchain technology, one of the common concerns is if the process implemented with blockchain technology will be recognized by the legal authorities, mostly in the case of a dispute. |
| Blockchain being used / proposed | At this point Ethereum on Azure. |
| Type of consensus algorithm used (if the blockchain is private or permissioned / consortium-based) | Permissioned Blockchain. |
| Rationale and trade offs considered when selecting a blockchain | The BoL is sensitive to the 'double spending' problem: the same digital file being 'copy-and-pasted' and transferred multiple times.<br>For that reason, existing digital signature solutions are not enough to digitalize but blockchain technology offers a solution. |

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| | Using Smart contract and workflow will reduce handling time, especially when changes are made in a BoL. |
| Any special hardware or other used (IoT, QR codes, etc.) | |
| Any open-source software being used / proposed | |
| Links to related information including technical white papers | https://ipcsa.international/armoury/resources/ipcsa-blockchain-solution-for-bol-21-05-2018-1.pdf |
| Other | |

# Annex II: Global Trade Digitization (GTD) – Maersk and IBM initiative

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| Section / Sector | Section III: Maritime Trade |
| Short description | Global Trade Digitization (GTD) is a trade platform for containerized shipping connecting the entire supply chain ecosystem. In august 2018 it changed it's name to Tradelens. |
| Proposing / Implementing / Testing Organization | Maersk and IBM |
| Contact for further information | https://www.tradelens.com/connect/ |
| Long description | The project's vision is to reduce global trade barriers and increase efficiency across international supply chains, provide an open industry platform enabling a rich ecosystem to seamlessly connect and securely exchange information, enable paperless trade by digitizing and automating document workflow.<br>GTD consists of two components:<br>- The Shipping Information Pipeline (SIP) provides end-to-end supply chain visibility that enables all actors involved in a global shipping transaction to securely and seamlessly exchange shipment events in real time (this feature is not based on blockchain technology).<br>- Paperless Trade digitizes and automates paperwork filings by enabling end users to securely submit, stamp and approve documents across organizational boundaries.<br>Following a successful pilot across several trade lanes in Africa, Europe and the U.S. earlier in 2017, Involvement across a much broader set of players is now being sought. |
| Description of potential business benefits from blockchain use | Assurance of the authenticity and immutability of digital documents; trusted cross-organizational workflows.<br>Enable paperless trade by automating document workflow. |
| Special concerns (legal, technical, etc.) | A vehicle ensuring the independence of GTD is being established and is considered critical to success. |
| Blockchain being used / proposed | GTD is built on an open technology stack and is underpinned by Hyperledger Fabric Blockchain technology.<br>Access via REST APIs (Application Programming Interfaces) enable integration with other workflow systems or enterprise software.<br>IBM hosts the solution on the IBM Cloud and the IBM high-security business network, delivered via IBM Bluemix. |
| Type of consensus algorithm used (if the blockchain is private or permissioned / consortium-based) | Permissioned Blockchain. |
| Rationale and trade offs considered when selecting a blockchain | |
| Any special hardware or other used (IoT, QR codes, etc.) | |
| Any open-source software being used / proposed | |
| Links to related information including technical white papers | Tradelens website: https://www.tradelens.com<br>Maersk and IBM collaboration press release: http://www-03.ibm.com/press/us/en/pressrelease/(&è&é.wss<br>What is GTD (Douane Cassandra Video): https://www.youtube.com/watch?v=jqdGvjUVNA&<br>IBM and Maersk Demo: Cross Border Supply Chain Solution on Blockchain: https://www.youtube.com/watch?v=dcddYatMCGQ&feature=youtu.be |

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| | Blockchain: A Better Way to Track Pork Chops, Bonds, Bad Peanut Butter?: https://www.nytimes.com/2017/03/04/business/dealbook/blockchain-ibm-bitcoin.html?_r=1 |
| Other | |

# Annex III: WaveBL – Blockchain Bill of Lading

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| Section / Sector | Section III: Maritime Trade |
| Short description | A solution that allows the secure exchange of original documents on the blockchain. |
| Proposing / Implementing / Testing Organization | WaveBL |
| Contact for further information | http://wavebl.com/#contact |
| Long description | Wave provides a network for exchanging unique documents and documents of title (including bills of lading) using blockchain technology, replacing their paper-based equivalent. Possession and Title could be transferred from one party to another without the need of a central registry, thus cargo could be claimed for the carrier by the receiving titleholder.<br>The product has reached its commercial stage and is used by several parties, Performed a pilot with ZIM Lines which commenced offering of the WAVEBL product to its clients. Currently evaluated by several more carriers and freight forwarders and banks. |
| Description of potential business benefits from blockchain use | The secure, digital transfer of the possession over unique documents and their title from one party to another. |
| Special concerns (legal, technical, etc.) | The Wave B/L bylaws are based on English law. |
| Blockchain being used / proposed | A designated blockchain is been developed and used. |
| Type of consensus algorithm used (if the blockchain is private or permissioned / consortium-based) | Public Blockchain with Permissioned mining. |
| Rationale and trade offs considered when selecting a blockchain | |
| Any special hardware or other used (IoT, QR codes, etc.) | None |
| Any open-source software being used / proposed | |
| Links to related information including technical white papers | https://www.coindesk.com/wave-blockchain-trade-finance-barclays/<br>http://wavebl.com<br>https://www.zim.com/news/press-releases/zim-s-blockchain-based-bl-s-initiative |
| Other | |

# Annex IV: Port of Antwerp blockchain pilot

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| Section / Sector | Section III: Maritime Trade |
| Short description | Antwerp Port have started piloting a blockchain solution for the container release procedure from the port. |
| Proposing / Implementing / Testing Organization | T-Mining (Belgian software startup) for the Port of Antwerp. |
| Contact for further information | https://t-mining.be/contact-us |
| Long description | This project is a solution for a specific data handling problem at the Port of Antwerp: when an import container arrives today, it is collected from the terminal in Antwerp by a truck driver or shipper, who is in possession of a PIN code. The PIN code is transmitted by e-mail through a number of parties, creating the risk of theft or fraud.<br>A pilot project is currently running in the port of Antwerp with a limited number of parties and has already handled its first container transactions in Antwerp, in cooperation with PSA and MSC.<br>Selected companies participating in the tests also include an unnamed forwarder and a transporter, with the aim to developing a commercial product.<br>This solution will give truckers, shippers and other parties greater security when coordinating a container’s release. |
| Description of potential business benefits from blockchain use | This blockchain platform ensures that the right truck driver is given clearance to collect a particular container, without any possibility of the process being intercepted. Furthermore, this blockchain platform uses a distributed network, so that the transaction can go ahead only if there is consensus among all participating parties, excluding any attempts at fraud or undesired manipulations.<br>This will also ultimately lower administration costs for manual corrections, as blockchain creates instant consensus on data using a common platform for all stakeholders involved in container transport.<br>As an unalterable ledger, blockchain will also verify authorizations of all the required parties for container release.<br>We consider improved data sharing as well. Next to the data of the pickup right (container number, name of the trucker, etc) we have developed an additional use-case on Next-Mode-of-Transport - building further on the Secure Container Release case - allowing data sharing between the Terminal (interested in Next Mode of Transport being truck, rail or barge - to improve yard stacking efficiency) and the freight forwarder and or shipper (interested in Estimated Time of Discharge to improve planning). |
| Special concerns (legal, technical, etc.) | |
| Blockchain being used / proposed | Ethereum |
| Type of consensus algorithm used (if the blockchain is private or permissioned / consortium-based) | Permissioned Blockchain. |
| Rationale and trade offs considered when selecting a blockchain | The "double spending" issue as a key consideration for the PIN code use-case. Today, organized crime units offer up to EUR 100k for PIN codes as duplicating it does not create any digital trace and thus a relatively easy & safe way to loophole today's security processes. |
| Any special hardware or other used (IoT, QR codes, etc.) | |
| Any open-source software being used / proposed | |
| Links to related information including technical white papers | https://maritime-executive.com/article/port-of-antwerp-trials-blockchain-software-system |

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| | http://www.coindesk.com/europes-second-largest-port-launches-blockchain-logistics-pilot/ http://www.portofantwerp.com/en/news/antwerp-start-t-mining-develops-blockchain-solution-safe-efficient-container-release |
| Other | |

# Annex V: 300cubits – TEU cryptocurrency

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|---|---|
| Section / Sector | Section III: Maritime Trade |
| Short description | A cryptocurrency for container liners and their customers to reduce counterparty risk of default of a cargo shipping agreement, i.e. a booking. |
| Proposing / Implementing / Testing Organization | 300cubits.tech |
| Contact for further information | https://www.300cubits.tech/contact-us/ |
| Long description | In the view of 300cubits, the source of industry losses is largely based on the industries missing ability to execute agreements in its daily operations and forecast for future business cycles or hedge the cyclical nature of the industry.<br>Contract default occurs when the customer does not turn up with the cargo according to the confirmed booking, or the container liner does not load the cargo delivered by the customer to the loading port. With this solution, TEU tokens will be provided by both counterparties during a shipment booking process. Then, the TEU token acts as a form of digital collateral, or booking deposit, which is payable per agreed terms by the defaulting party.<br>The longer term vision is for the TEU currency to be used as settlement currency for the container shipping industry, which could move much of the maritime industry's transactions, and the entire logistics industry's transactions, onto the blockchain. |
| Description of potential business benefits from blockchain use | Reduction in the 30 billion a year in losses caused by “no-show” bookings. Using smart contracts to execute the swap of digital assets, the "TEU" currency will allow use of digital collateral in order to “enforce” shipment bookings. |
| Special concerns (legal, technical, etc.) | Global legal acceptance and the regulators role in cryptocurrencies are constantly changing.<br>The legal enforceability of a transaction, using the ledger as a proof, has to yet been confirmed by a court of law. |
| Blockchain being used / proposed | Ethereum |
| Type of consensus algorithm used (if the blockchain is private or permissioned / consortium-based) | |
| Rationale and trade offs considered when selecting a blockchain | |
| Any special hardware or other used (IoT, QR codes, etc.) | |
| Any open-source software being used / proposed | |
| Links to related information including technical white papers | https://www.300cubits.tech/pdf/whitepaper.pdf |
| Other | |

# Annex VI: SmartLog – Muuga Harbour, Tallin, Estonia

| Section / Sector | Section II: Supply chain transparency |
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| Short description | SmartLog, a message storage and relaying platform, enables monitoring in near-real time of intermodal supply chain operations such as loading, unloading, storing and transporting freight items. |
| Proposing / Implementing / Testing Organization | SmartLog, a Finnish-Swedish-Estonian-Latvian project, financed by the European Regional Development Fund under the EU's Interreg Central Baltic program, with a budget of 2.4 million euros and lasting 3 years (ending in February 2020), has Kouvola Innovation Oy (Finnish regional non-profit business development company) as its the leading partner. |
| Contact for further information | https://smartlog.kinno.fi/contact |
| Long description | This system substantially improves supply chain operators resource efficiency, reduces manual work processes and bureaucracy while accelerating all the processes.<br>The new technology improves time efficiency and accuracy both for forwarders and transport companies, reduces traffic loads, eliminates cumbersome bureaucracy from logistics and excludes the use of multiple, duplicate data.<br>SmartLog is being tested as an underlying messaging solution to the existing EDI and Single Window solutions. A demonstration was performed at Muuga Harbour in Estonia and another demonstration is on-going in Finland with Metsä Group, VR Transpoint, Kouvola Cargo Handling, Schenker, and Finnish Customs. A third demonstration is being prepared in Sweden.<br>Both use cases aim at connecting the transporting companies' operations management systems together on the messaging level, and providing more and better quality data to the involved stakeholders in the course of completing an individual supply chain instance. |
| Description of potential business benefits from blockchain use | So far this project has discovered two main areas, where blockchain can deliver potentially additional value:<br>A. Time accuracy and efficiency metrics improvement, resulting from almost complete transparency within a supply chain in question, enabling allocating resources just-in-time;<br>B. Near-complete audit trails resulting from recording the involved parties messaging data into the blockchain and storing it there for further access and analysis. |
| Special concerns (legal, technical, etc.) | |
| Blockchain being used / proposed | Linux Foundation's Hyperledger Fabric.<br>They used a local and cloud-based Hyperledger instances. |
| Type of consensus algorithm used (if the blockchain is private or permissioned / consortium-based) | Permissioned, consortium-based blockchain. |
| Rationale and trade offs considered when selecting a blockchain | Hyperledger Fabric was chosen given the consortium behind its development, and the stated goal of becoming the industrial blockchain development framework. |
| Any special hardware or other used (IoT, QR codes, etc.) | |
| Any open-source software being used / proposed | Hyperledger Fabric |
| Links to related information including technical white papers | http://www.portoftallinn.com/news?art=872<br>https://www.propentus.com/en/propentus/news/item/541-propentus-provides-trust-in-smartlog-the-project-for-iot-blockchain-solution-in-logistics-industry |

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| | https://cointelegraph.com/news/finnish-city-partners-with-ibm-to-validate-blockchain-application-in-logistics<br>https://smartlog.kinno.fi/articles/project-smartlog-blockchain-logistics<br>https://github.com/project-smartlog/ |
| Other | |

# Annex VII: SOLAS VGM

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|---|---|
| Section / Sector | Section III: Maritime Trade |
| Short description | Collaborative ecosystem between all land-side parties, the loading point, shipper, driver, booking party, terminal and shipping line to provide a Verified Gross Mass (VGM) for every packed container as a condition for vessel loading. |
| Proposing / Implementing / Testing Organization | Marine Transport International – MTI |
| Contact for further information | http://solasvgm.com/contact/ |
| Long description | The International Maritime Organization (IMO) regulation under the Safety of Life at Sea Convention (SOLAS) requires shippers to provide a Verified Gross Mass (VGM) for every packed container as a condition for vessel loading.<br>This took effect in July 1, 2016.<br>The SOLAS VGM solution will allow businesses to create their own ecosystems with supply chain parties. Through these ecosystems, the VGM will be provided to the terminal, before the Gate-In event.<br>User interface software allows data to be collected earlier in the supply chain. This is written onto a blockchain and then any party in the supply chain able to view the data which has been created between parties in the ecosystem.<br>The mobile app is suited for use at loading points, weigh bridges and by drivers.<br>The shipping lines' booking number is the unique reference along with the container, which links parties together. Shippers allow access to their supply chain via authorization to parties within the supply chain through the application.<br>Weigh bridge tickets along with any other paperwork can be uploaded at this point to the blockchain, via Android or Apple operating systems. This allows a clear audit trail of the VGM and final sign off by the shipper to the shipping line.<br>The web application is suitable for office-based staff monitoring the loading of the containers and creation of shipping documents based on details surrounding the container |
| Description of potential business benefits from blockchain use | Previously, data has been deeply ingrained in old legacy systems. This causes delays in the development of new capabilities, hindering the ability for carriers to make rapid changes to services.<br>The blockchain is a data structure that makes it possible to overcome these issues, creating a permanent digital public ledger of transactions. The use of blockchain, to increase trust and audit process. |
| Special concerns (legal, technical, etc.) | |
| Blockchain being used / proposed | TrustMe™ public blockchain technology |
| Type of consensus algorithm used (if the blockchain is private or permissioned / consortium-based) | N/A |
| Rationale and trade offs considered when selecting a blockchain | |
| Any special hardware or other used (IoT, QR codes, etc.) | Pictures from mobile devices can be stored and uploaded to SolasVGM™. |
| Any open-source software being used / proposed | |
| Links to related information including technical white papers | http://solasvgm.com/<br>http://solasvgm.com/wp-content/uploads/2016/09/SOLASVGM™-Handbook.pdf<br>https://www.ccn.com/first-operational-use-public-blockchain-technology-global-shipping-industry-announced/ |
| Other | |

# Annex VIII: Table grapes pilot

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|---|---|
| Section / Sector | Section V: Agricultural, fisheries and food trade |
| Short description | Table grapes pilot: Certification process and usage of certificates in the (international) fresh fruit supply chain |
| Proposing / Implementing / Testing Organization | |
| Contact for further information | Ge, Lan lan.ge@wur.nl<br>Frans van Diepen frans.vandiepen@rvo.nl |
| Long description | This Table grapes pilot project was undertaken as part of the public private partnership (PPP) project 'Blockchain for Agrifood' that was started in March 2017. The project aims to contribute to a better understanding of blockchain technology (BCT) and its implications for agrifood and what is needed to apply BCT in agrifood supply chains (For more information on the project see "Links" below). To implement the proof of concept for table grapes from South Africa, a demonstrator was built that keeps track of different certificates used in the table grapes supply chain. The code for this demonstrator is published on Github. |
| Description of potential business benefits from blockchain use | In the current situation, much of the compliance data and information is audited by trusted third parties and stored either on paper or in a centralised database and these approaches are known to suffer from many problems. Notable problems are:<br>• The high cost and inefficiency of paper-based processes.<br>• Fraud, corruption, error both on paper and in IT systems.<br>• Integrity of digital records (problems due to human error and data tampering).<br>• Double-spending (use) of certificates. BCT can improve this situation for : Registration of holdings, animal, plant and transactions;<br>• Tracking and tracing of products with credence attributes (i.e., qualities that are not directly observable by users or end consumers).<br>This can potentially enhance developments in true pricing (or true cost accounting) that aim to convey information on the externalities of food production;<br>• Transfer of import & export certificates (e.g., SPS certificates);<br>• Inclusive development by ensuring access of smallholders to better market and better payments or financing possibilities (e.g., FairFood, AgriLedger);<br>• • Creating opportunities for automating business processes triggered by a transaction that meets defined conditions (in the case where smart contracts are used); |
| Special concerns (legal, technical, etc.) | It is important to identify areas where there is a business case for key stakeholders to apply blockchain including viable business models and governance. Food integrity and inclusive development are two key themes in this regard.<br>• Scalability (technological – throughput in in terms of number of transactions).<br>• Digital to physical interface: connecting BCT applications with precision agriculture, big data, sensors and IoT platforms, connecting to electronic readable labels (identifiers of physical goods) such as RFID, barcode or 2D grid codes and event recording. The recorded event can be included in a blockchain on this product/supply chain;<br>• Semantic models and data models – specifically the integration of existing data models with BCT so as to enable wider interoperability.<br>• • Querying of data on the blockchain, and access management. |
| Blockchain being used / proposed | A permissioned implementation of Hyperledger Fabric |

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| Type of consensus algorithm used (if the blockchain is private or permissioned / consortium-based) | N/A |
| Rationale and trade offs considered when selecting a blockchain | Support for identity management<br>Privacy (EC's General Data Protection Regulation(GDPR) Scalability:<br>• Limited transaction speed<br>• Limited payload size<br>• Transaction cost<br>• • Irrelevant data Interoperability with other information systems<br>• Support for smart contracts |
| Any special hardware or other used (IoT, QR codes, etc.) | N/A |
| Any open-source software being used / proposed | published on GITHUB: https://github.com/JaccoSpek/agrifood-blockchain |
| Links to related information including technical white papers | http://library.wur.nl/WebQuery/wurpubs/530264 |
| Other | |

# Annex IX: Coconut Pilot

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| Section / Sector | Section V: Agricultural, fisheries and food trade |
| Short description | Blockchain based traceability and claim verification in a coconut supply chain. |
| Proposing / Implementing / Testing Organization | Fairfood |
| Contact for further information | Marten van Gils, marten@fairfood.nl, +31 641576980, blockchain.fairfood.nl |
| Long description | In this pilot a blockchain-enabled system (Provenance) was co-developed and implemented in a small fresh coconut supply chain to:<br>a) trace individual coconuts from the farm in Indonesia to the point of sale in the Netherlands, and<br>b) verify that a fair price was paid without using a certifier.<br>The goal was to prove that a blockchain-enabled system that could be used to this end and explore the pros and cons for future reference.<br>PROCEDURE. 55 farmers, 1 supplier (Aliet Green), 1 retailer (fairfood) and 1 consumer were provided with a blockchain address. On harvest day, the farmers used their cell phones (e.g. simple Nokia's) to register their harvest (e.g., 16 coconuts) and tag them with their unique farmer code and offer them to the supplier via the system. Two days later the supplier checked the offer and paid out the farmer a fixed price in cash for each coconut. The fixed (fair) price consisted of the standard market value plus a living income premium that we calculated on the basis of the Anken&Anker methodology. Farmers confirmed with their fingerprint that they received the full amount. One day later, they received an SMS asking whether they indeed received the correct amount, to which they had to answer yes/no. After collecting the nuts, the supplier accepted the farmers' offer via the system, packaged and offered the nuts to the retailer, who accepted the offer after the conditions were met. After receipt of the nut in the Netherlands, the retailer tagged each individual nut with a Qr code based on the farmer tag and sold most of them on Theater Festival De Parade. One nut was offered to and accepted by a consumer via the system to complete farm-to-fork chain of custody. By scanning the QR code, consumers could trace the provenance of their specific coconut and consumers were given the opportunity to thank the farmer for the coconut, by sending a standardized SMS message through the system.<br>RESULTS. 50/55 farmers successfully registered their harvest on the system using their phones, while 5/55 were unable to do it because of network connectivity problems in their remote location. They were therefore excluded from the data-set. 50/50 farmers put their fingerprint on the collector's paper to confirm they received the agreed (fair) price, whereas 8 of the same 50 farmers said via SMS they did NOT receive the agreed (fair) price.<br>The retailer (Fairfood) saw in the system that not all coconuts were correctly paid for, so they notified the supplier that the core condition (fair price) in the purchase agreement wasn't met and that they wouldn't buy any coconuts until all were fair, as stipulated in the agreement. It turned out that in all 8 cases, the farmer had indeed not been paid in full, so within one day the supplier made another payment run and the remaining 8 fair price verification came in through the system. Then the retailer paid for and accepted the supplier's offer and offered the coconut to consumers, one of whom accepted the coconut through the system to complete the chain of custody. An estimated half of the consumers scanned the QR code on their nut and a total of 52 Thank You sms's were sent by consumers to the farmer that produced their coconut.<br>CONCLUSIONS. The blockchain-enabled system proved to be able to provide radical farm-to-fork traceability of a coconut supply chain. The fact that all actors, including the 50/55 farmers – most of them elderly, poorly educated and using simple phones – were able to participate in this pilot with relative ease, confirms that the technical infrastructure is sufficient for this system to work. We conclude that if it works there, it should work in all areas with cell phone network coverage and basic Internet connectivity. Supplier, retailer and consumer easily offered and/or accepted digital assets through the system to complete the chain of custody. Consumers |

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| | responded very enthusiastically to being able to see where their coconut came from, who made it and what was paid for it. Note that this result isn't regarded as representative per se, because a lot of instruction and attention was given to each consumer. Last, but not least, the fact that 8 farmers used the (anonymous) system to claim that they hadn't received a fair price, whereas all of them confirmed with their fingerprint that they had, is an indicator that if you give farmers control over their digital assets, they can use it to provide more reliable information and can use their control over their digital assets to make sure they get paid a fair price. We regard this as the most significant outcome of the project and something that deserves more exploration. |
| Description of potential business benefits from blockchain use | Traceability, claim verification, marketing |
| Special concerns (legal, technical, etc.) | Scalability of systems, privacy (e.g. publishing farmer income), making VERY clear agreements in advance with supply chain actors. |
| Blockchain being used / proposed | Provenance is based on Ethereum |
| Type of consensus algorithm used (if the blockchain is private or permissioned / consortium-based) | Proof of work (then) |
| Rationale and trade offs considered when selecting a blockchain | The most considered choice was for Provenance and we went along with whatever blockchain they used. |
| Any special hardware or other used (IoT, QR codes, etc.) | Phones, QR codes, tags |
| Any open-source software being used / proposed | N/A |
| Links to related information including technical white papers | blockchain.fairfood.nl<br>https://www.youtube.com/watch?v=aLAVoYDwYAM<br>https://fairfood.nl/wp-content/uploads/2018/01/Position-Paper-On-Blockchains-1.pdf |
| Other | |

# Annex X: Winding Tree

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| Section / Sector | Section VII: Tourism |
| Short description | Winding Tree (WT) is a decentralized open-source travel distribution platform. |
| Proposing / Implementing / Testing Organization | Implementing |
| Contact for further information | Winding Tree Stiftung, Gubelstrasse 11, 6300 Zug, Switzerland, CHE 415. 029. 859, https://windingtree.com/ |
| Long description | WT is a decentralized (not controlled by a single entity) marketplace for travel companies, where suppliers (airlines, hotels, etc.) and buyers (travel agencies) can trade. Because there is no intermediary, the transaction fees are eliminated (WT doesn't take any transaction fees). Moreover, the middlemen can't act as gatekeepers of the industry anymore, allowing for a much faster pace of innovation.<br>WT already partnered with a few airlines (Lufthansa, Air France/KLM, Air Canada, Air New Zealand) and hotel groups (Nordic Choice Hotels, Citizen M, Airport Hotel Basel). They plan to expand their activities into other parts of the travel industry (car rentals, tours and activities, etc.) |
| Description of potential business benefits from blockchain use | Currently, the travel indstry is dominated by 5 large corporations (Expedia, Priceline, Sabre, Amadeus, Travelport). These intermediaries charge excessive fees on every transaction (hotels - up to 25%, airlines - 16 euro per booking). Moreover, they control the market completely, being able to decide who can participate in the market and who can't, effectively stifling innovation in the travel industry and limiting it to their own initiatives.<br>Winding Tree, with it's decentralized marketplace, solves the above problems |
| Special concerns (legal, technical, etc.) | Legal concerns: N.A.<br>Technical concerns: Winding Tree had successfully overcome the concern around the transaction throughput of public blockchains (specifically Ethereum). |
| Blockchain being used / proposed | Ethereum |
| Type of consensus algorithm used (if the blockchain is private or permissioned / consortium-based) | Ethereum proof-of-work. |
| Rationale and trade offs considered when selecting a blockchain | Ethereum is used because it could provide smart contract capabilities and handle more transactions per second. |
| Any special hardware or other used (IoT, QR codes, etc.) | Special hardware used: N.A. |
| Any open-source software being used / proposed | WT code is open-source and completely transparent for anyone to study: https://github.com/windingtree. |
| Links to related information including technical white papers | https://windingtree.com/suppliers.html<br>https://windingtree.com/files/White_Paper_EN.pdf<br>https://windingtree.com/files/WT_OP_ENG.pdf<br>http://www.businesstravelnews.com/innovators-you-should-know/2017/winding-tree<br>https://www.tnooz.com/article/lufthansa-invests-blockchain-partners-winding-tree/<br>https://www.coinjinja.com/ico/winding-tree |
| Other | |

# Annex XI: TUI case study

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| Section / Sector | Section VII: Tourism |
| Short description | TUI, a German travel-related company and one of the largest in the world, made it public in 2017 that they would adopt blockchain technologies in their booking, reservation, and payment systems. |
| Proposing / Implementing / Testing Organization | Implementing within the company group |
| Contact for further information | Mr. Kuzey Esener +49 (0) 511 566 6024; kuzey.esener@tui.com; Corporate Spokesperson/Head of Media Relations on the presented paper :“TUI 2022“. Fritz Joussen, CEO, presented this new program for the future at Annual General Meeting |
| Long description | TUI has a strategy to shift from a conventional travel product distribution system, to one using blockchain technologies. TUI has moved all of its contracts related to bedstock (i.e. beds in hotels and other facilities) to the blockchain environment, and has started working with these technologies. The hotel inventory has also been transferred into a blockchain environment in order to manage it more efficiently. It has been completed successfully. |
| Description of potential business benefits from blockchain use | They expect cost savings and revenue growth from using blockchain technologies. |
| Special concerns (legal, technical, etc.) | N/A |
| Blockchain being used / proposed | Ethereum |
| Type of consensus algorithm used (if the blockchain is private or permissioned / consortium-based) | Private |
| Rationale and trade offs considered when selecting a blockchain | TUI adopts Ethereum to use Smart Contracts |
| Any special hardware or other used (IoT, QR codes, etc.) | N/A |
| Any open-source software being used / proposed | N/A |
| Links to related information including technical white papers | https://www.tuigroup.com/en-en/media/stories/special-themed-section/digitalisation-and-innovation/2017-08-16-what-is-a-blockchain<br>https://thebitcoinnews.com/tui-tourism-group-will-adopt-ethereum-blockchain-technology/<br>https://btcmanager.com/tui-tourism-group-to-adopt-ethereums-blockchain/<br>http://ftreporter.com/tui-group-uses-blockchain/<br>https://www.phocuswire.com/TUI-Group-blockchain-development<br>https://skift.com/2017/07/11/blockchain-will-disrupt-expedia-and-airbnb-tui-ceo-says/ |
| Other | |

# Annex XII: IrisGuard UK Ltd.

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| Section / Sector | Section IX: Blockchain supporting the UN SDGs |
| Short description | IrisGuard UK Ltd. is the world leader in iris recognition technology that authenticates identity for large-scale humanitarian deployments. Partnered with the World Food Programme’s (WFP) 3private Ethereum, over $100,000 is transacted daily using the iris to secure the last mile in blockchain authorization.<br>SDGs in Focus: 16.9, 5.9, 2.1 and 1.4 |
| Proposing / Implementing / Testing Organization | IrisGuard UK Ltd, 43 Shenley Pavilions, Chalkdell Drive, Shenley Wood, Milton Keynes MK5 6LB, United Kingdom |
| Contact for further information | Imad Malhas, CEO, imalhas@irisguard.com, +44 1908 991683 |
| Long description | In 2017, IrisGuard made the pioneering step of coupling its patented EyePay® retail POS system with the WFP’s private permissioned version of Ethereum blockchain; resulting in the largest private Ethereum implementation the world has seen to date. Using iris recognition to overcome the weakest link in the Blockchain, which is the cryptic private key, IrisGuard’s 100% accuracy through its iris recognition platforms ensures that the key cannot be lost, stolen, forged, copied or forgotten.<br>Thus, large-scale humanitarian deployments of blockchain payments are now possible, eliminating fraudulent transactions and misappropriation of funds, and therefore stretching donor funds even further.<br>Additionally, the blockchain automatically records transactions on a secure ledger, with instantaneous merchant settlement, which means shorter payment cycles in comparison to traditional banking and third-party processor methods, something that merchants have welcomed tremendously.<br>Following a successful and secure pilot, the project was rolled out to additional retail outlets in Jan 2018, multiplying both the number and value of transactions into tens of millions of dollars. |
| Description of potential business benefits from blockchain use | The weakest link of any Blockchain is the storing and handling of the cryptic private key, securing authentication and preventing fraudulent use.<br>Iris recognition in lieu of the 32-byte cryptic key in conjunction with the EyePay® retail POS platform allows secure and fast transaction authorization, which is essential for a real-time application such as a supermarket.<br>Authorization and settlement of POS transactions are made outside of the traditional banking system, therefore eliminating transaction fees (usually 1.75%). This allows WFP to stretch their donor funds replacing bank with blockchain.<br>Beneficiaries who have no access to the banking system are also provided with dignified financial inclusion, allowing them to feed their families using only their iris to securely authenticate identity and authorize a retail transaction.<br>WFP does not have to provide funds in advance to a bank to be held “on account” for beneficiaries’ individual retail transactions. The blockchain ledger replaces the need to make these large financial deposits.<br>Donors are reinvigorated in the knowledge that the robust EyePay® platform ensures that transactions are 100% accurate and only the intended beneficiary can use the funds. Therefore, fraudulent transactions to “ghost” recipients, which is often an unfortunate consequence of card or voucher-based aid distribution, are completely eliminated. Settlement of monies is immediate for merchants, so they are paid faster by not being dependent on bank transaction reconciliation, which can add months to the normal payment cycle. Merchants also benefit from knowledge of the exact products purchased, allowing them to better forward-plan in terms of stock turnover and replenishment. |
| Special concerns (legal, technical, etc.) | The real-time nature of the supermarket Point of Sale (POS) system that serves refugees puts tremendous pressure on any platform to perform. IrisGuard’sEyePay® hardware offers unrivalled iris imagery (significantly exceeding the ISO standard), operational integrity, and durability. It is also built to withstand extreme environmental conditions. Similarly, the software guarantees an airtight method of |

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| | creating Unique Verifiable Identities, providing a one-to-millions real-time iris authentication and ensuring an 0% error rate with no false positives.<br>Additionally, EyePay® needs to integrate securely and seamlessly with the WFP's Ethereum blockchain and be 100% reliable around-the-clock, and throughout the year. |
| Blockchain being used / proposed | Ethereum |
| Type of consensus algorithm used (if the blockchain is private or permissioned / consortium-based) | Private permissioned |
| Rationale and trade offs considered when selecting a blockchain | The rationale behind selecting the Ethereum blockchain was to:<br>• release dependence on local banks,<br>• eliminate transaction fees of approx. 1.75% per transaction,<br>• beter and quicker response to crisis,<br>• better cashflow for merchants who are paid faster as settlement is immediate,<br>• money not held by bank,<br>• reinvigoration of donors by providing them with a cost effective and robust platform coupled with Blockchain that they can trust to accurately deliver, with extremely high efficiency unseen before in humanitarian aid. |
| Any special hardware or other used (IoT, QR codes, etc.) | IrisGuard camera systems: AD100 and EyeHood®<br>Iris-enabled Point of Sale: EyePay® POS<br>Iris-enabled mobile phones: EyePay® Phone |
| Any open-source software being used / proposed | N/A |
| Links to related information including technical white papers | www.irisguard.com<br>www.twitter.com/irisguard<br>www.facebook.com/irisguard<br>www.linkedin.com/company/irisguard<br>https://innovation.wfp.org/project/building-blocks |
| Other | SDG 16.9 provide legal identity for all, including birth registration<br>SDG 5.9 enhance the use of enabling technology, in particular information and communications technology, to promote the empowerment of women<br>SDG 2.1 end hunger and ensure access by all people, in particular the poor and people in vulnerable situations<br>SDG 1.4 ensure that all men and women, in particular the poor and vulnerable, have equal rights to economic resources |

# Annex XIII: Datafund

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| Section / Sector | Section IX: Blockchain supporting the UN SDGs |
| Short description | Datafund enables a fair and sustainable data economy with the goal to be inclusive for all and to contribute to value created UBI. Moreover, with the non- profit division Fair Data Society, we are introducing the concept of Fair data (similar to Fair trade) to promote inclusiveness and equal opportunity. |
| Proposing / Implementing / Testing Organization | Datafund.o.o., Slovenia (registration id: 8097135000) |
| Contact for further information | Gregor Žavcer, cofounder, director of development, gregor@datafund.io, +386 41 792675, @jssr (twitter), /inholodeck (linked in), |
| Long description | Datafund project is a protocol and a distributed application (dApp) that guards personal data, provides safe storage and enables provable personal data exchange. Information is shared anonymously or on a need-to-know basis according to an agreement between the exchanging parties.<br>Because the processing of personal data should be designed to serve mankind, very strict privacy protection regulations such as GDPR are being embraced globally, providing the path for individuals to reclaim their data.<br>Only a decentralized solution puts the individual into control of her data while allowing censorship-proof exchange of data without intermediaries. Moreover, applying blockchain technology allows for creation of an "individual-centric" process that allows for unprecedented economic efficiency for all parties involved. Datafund protocol is built on Ethereum and Swarm with the intent to be blockchain and technology agnostic as much as needed.<br>Datafund network consists of various individually owned datafunds. Datafund (as a structure/model) is a new form of personal data oracle and a data market where organizations are incentivized to give data back to individuals, and to participate in a fair and ethical exchange of data value. Contributors to a specific datafund are rewarded with intrinsic tokens of a receiving datafund. |
| Description of potential business benefits from blockchain use | Enterprises increase security while lower costs regarding personal data management. Moreover, with blockchain and decentralized storage solutions, enterprises can increase integrity of their data, have efficient control and censorship resistant audit logs that prevent misuse of personal data. Putting the individual back in control of data, enables also businesses to monetize data in partnership with individuals which offers unprecedented possibilities how data can be merged and utilized. Our first product, fairdrop.xyz enables secure file transfer and we see that business already have the need for that, to not be dependent on tech giants' infrastructure. |
| Special concerns (legal, technical, etc.) | Privacy and data protection laws such as GDPR in Europe. |
| Blockchain being used / proposed | Short-term: Ethereum, long-term: blockchain agnostic |
| Type of consensus algorithm used (if the blockchain is private or permissioned / consortium-based) | N/A |
| Rationale and trade offs considered when selecting a blockchain | Censorship resistant, data owned by individuals, privacy |
| Any special hardware or other used (IoT, QR codes, etc.) | We will use QR codes for users to grant access to data in physical locations |
| Any open-source software being used / proposed | Many, especially in the Ethereum and Swarm ecosystems |
| Links to related information including technical white papers | https://docs.google.com/document/d/1PzfN5lPzzYA_c72KNkq3-568NBluF12U63HQPH2bPsM/edit#heading=h.cvpoz2f703mb |

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| | https://datafund.io/papers/Datafund_Business_Primer_Final_v09.pdf<br>https://blog.datafund.net/reclaim-your-data-reclaim-freedom-78f39fce0a92 |
| Other | SDGs in focus: 1 (1.1, 1.4), 8 (8.1.1), 9 (9.1), 10 (10.1, 10.2, 10.3), 16 (16.9, 16.10) |

# Annex XIV: ODEM

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| Section / Sector | Section IX: Blockchain supporting the UN SDGs |
| Short description | ODEM provides a network and marketplace that connects educators, students and employers directly to provide education and employment opportunities leveraging blockchain technology. Because of its decentralized and cross-border platform, ODEM can thus improve management of education outcomes for distressed populations. |
| Proposing / Implementing / Testing Organization | ODEM SA, Switzerland |
| Contact for further information | Richard Maaghul CEO, Rich@odem.io , 415-798-6876, @ODEMIO Website: odem.io |
| Long description | Improving access to education resources is a priority for many major international NGOs. Better tools and more cost-effective means of delivering educational content are required. At present, there are a few tools that are tailored to create new educational opportunities and track these achievements in distressed environments where content delivery is irregular or nonexistent. In addition to blockchain technology enabling money as a digital asset, it also enables the digitization and secure sharing of educational credentials and a currency or asset as well. In this regard, Blockchain technology as the underlying protocol for digital currencies and digitized immutable certification provides a robust framework for creating, certifying , tracking and securely sharing educational programs, and securely managing student credentials. By leveraging blockchain encryption technologies to verify educators, accrediting entities and employers, ODEM shields end-user identities and credentials from bad actors, while at the same time empowering members of displaced populations with self-sovereign education credentials that they can monetize to become fully employed and continue to participate in lifelong learning both remotely and across borders. ODEM partners with digital wallet providers that can easily be used to manage digital credential assets and verify all educational activity through the use of its ODEM token and blockchain-based architecture. The ODEM Platform includes a system that addresses the issues of loss of educational identity for victims of involuntary migration by offering a model to re-establish academic and professional identity through its unique consensus verification model (Identity Through Education or ITE) to reclaim their already-earned credentials, dignity, and respect in order to participate and contribute at their full professional and personal capacity and accelerate their community's economic recovery. |
| Description of potential business benefits from blockchain use | ODEM's Blockchain Platform Provides:<br>• A currency and learning-modality agnostic platform, network and marketplace where students, educators and employers can connect directly to build new models of education and employment across borders for both in-person and online/remote learning.<br>• A course offering 'staking' model that allows students and educators to crowdsource new education opportunities while using blockchain technology and machine learning to identify trends and match student needs with educator skills and availability.<br>• Indelible record retention for education activities.<br>• Student-controlled educational credentials protected by industry-standard encryption.<br>• Auditable/traceable achievement records adaptable for life-long learning.<br>• Lower-cost sourcing of education programs.<br>• More flexible tools to deliver non-traditional programs. |

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| Special concerns (legal, technical, etc.) | Primary Concerns, and how ODEM is currently addressing these:<br>• ISSUE: Lack of legal recognition of individuals seeking education. SOLUTION: ODEM has developed a model of consensus verification that allows it to use human consensus to recreate an individual's academic identity.<br>• ISSUE: Insufficient legal protection for those involved in the delivery and verification of educational programs. SOLUTION: ODEM methods of KYE or Know Your Educator to verify educators identity and educational credentials.<br>• ISSUE: Inadequate legal framework and identity standards for Personally Identifiable Information. SOLUTION: ODEM maintains all PII on its secure encrypted proprietary system and at any time information can be removed to accommodate GDPR and privacy requirements.<br>• Lack of legal protection and guidance for custodianship of cryptographic keys linked to personal identities.<br>• Potential service disruptions from ISPs or unforeseeable network capacity problems related to the Ethereum Network.<br>• Physical security issues for students who have no assurance about their safety. |
| Blockchain being used / proposed | The ODEM platform was launched and is currently live on the Ethereum MainNet and IPFS Blockchain. Its structure includes the following:<br>• ODEM has created an ERC20 token (ODEM-T) based on the Ethereum Blockchain that is used to fuel smart contracts that drive all business models on the ODEM platform. All education programs and certification transactions are logged currently to the Ethereum network.<br>• In conjunction to leveraging Ethereum for secure, indelible transactions of all ODEM education activity and certification, ODEM leverages the IPFS (Interplanetary File System) blockchain to manage actual blockchain-based certificates. Since the Ethereum network currently does not support storage of data, IPFS has been chosen to work in conjunction with Ethereum to provide the most efficient and effective model of delivery of blockchain event capture and certification.<br>NOTE: See attached ODEM Ecosystem Graphic for complete system architecture. |
| Type of consensus algorithm used (if the blockchain is private or permissioned / consortium-based) | N/A |
| Rationale and trade offs considered when selecting a blockchain | Rationale: The most-developed smart-contract platform and digital token standards.<br>Trade-off: Reliance on the Ethereum blockchain's economics and infrastructure. |
| Any special hardware or other used (IoT, QR codes, etc.) | N/A |
| Any open-source software being used / proposed | ODEM has built its blockchain-based technology (currently leveraging Ethereum and IPFS) to be completely open-sourced. These platforms are used in conjunction with its own proprietary closed cloud-based platform and user interface to create a complete solution.<br>ODEM SA is in the final stages of establishing a sister foundation, ODEM Outreach, where it will assign official ownership of its open-source code base including all ODEM smart contracts and blockchain technology used to create credentials via IPFS. All systems that include PII, meta data and descriptors will remain proprietary to the ODEM SA company. |

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| | NOTE: See attached ODEM Ecosystem Graphic for complete system architecture. |
| Links to related information including technical white papers | https://odem.io/<br>https://www.youtube.com/watch?v=U79f_R9gyCE&t=20s<br>https://odem.io/wp-content/uploads/2019/01/ODEM.IO-Technical-Whitepaper.pdf<br>https://odem.io/what-is-odem-education-marketplace/<br>https://en.bitcoinwiki.org/wiki/ODEM<br>https://medium.com/odem/odem-to-partner-with-internet-bar-organization-to-aid-rohingya-953c6e161ce5<br>https://www.youtube.com/channel/UCFXMtmZtaJfsNtSLwzLliyA<br>https://www.youtube.com/watch?v=CxtcCXWCBL0 |
| Other | SDG in focus: GOAL 4: Access to Quality Education - Inclusive and Equitable Education to Promote Lifelong Learning for All. - Three out of four countries do not have sufficient data to track progress towards SDG Goal 4 targets for learning outcomes. 93.7% of the world's population currently does not attend college. |

# Annex XV: Saga

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| Section / Sector | Section IX: Blockchain supporting the UN SDGs |
| Short description | Growing out of the traditional financial world and respecting its norms and regulations, Saga is a global digital currency, guided by a non-sovereign monetary policy. |
| Proposing / Implementing / Testing Organization | SAGA Foundation, Switzerland, CHE-196.209.820 |
| Contact for further information | Full Name: RonSabo,Ph.D., Head ofResearch, ron.sabo@saga.org,: +972-528961622,: TW/FB: @SagaFoundation, www.saga.org |
| Long description | Saga, a non-profit foundation, is fusing blockchain technology with ideas about digital finance to create a global currency. Saga's currency is non-sovereign, intended to act as a safe store of value for all holders, regardless of their nationality or location. Saga does not aim to replace existing national currencies; on the contrary - it recognizes traditional roles of national money and coexists alongside them. For this mission, Saga has assembled a group of experts from a variety of disciplines and practices ensuring its currency has a robust monetary policy and a governance mechanism.<br>The emergence of such a global currency will make transacting more efficient and support economic growth in developing areas. Saga brings the benefits of secure financial services to both unbanked populations and to citizens of struggling economies. This enhances financial abilities and supports the growth of economies. Such growth in productivity and income are catalysts for improving many social conditions, such as health, education and sanitation. The Saga currency ensures that the right to hold a secure currency is universal, and is no longer just a privilege of citizens of developed countries.<br>As a fully compliant currency, Saga can promote a wider regulatory umbrella and reduce the diffusion of money into the black economy. It will help block funding of illegal activities such as corruption, bribery, and terrorism – therefore promoting the rule of law. The transparency inherent in blockchain technology, combined with Saga's regulatory approach, allows investors to make sure funds arrive to their intended destination. This will make investments much more attractive and expand the building of resilient infrastructure and sustainable industrialization. |
| Description of potential business benefits from blockchain use | Governance Mechanism and a Monetary Policy built upon Smart Contracts |
| Special concerns (legal, technical, etc.) | N/A |
| Blockchain being used / proposed | Ethereum is being used, however Saga is designed to have the ability to migrate to a different blockchain if necessary. |
| Type of consensus algorithm used (if the blockchain is private or permissioned / consortium-based) | N/A |
| Rationale and trade offs considered when selecting a blockchain | Scalability, widely adopted, ability for running dApps. |
| Any special hardware or other used (IoT, QR codes, etc.) | N/A |
| Any open-source software being used / proposed | N/A |
| Links to related information including technical white papers | https://www.saga.org/learnmore |
| Other | SDGs in Focus: SDG 1, 2, 8, 9, 10, 16: Regulatory compliance - promoting the rule of law, prevention of misallocation of funds, assurance of safe store of value |

# Annex XVI: Flying Carpet

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| Section / Sector | Section IX: Blockchain supporting the UN SDGs |
| Short description | An open network for building and using aerial analytics services. The Flyingcarpet network connects analytics-hungry businesses with a pool of data scientists who compete to create world-leading analytics-extraction models from rich visual data, such as drone and satellite imagery. |
| Proposing / Implementing / Testing Organization | AIR Network Ltd, Gibraltar, Registration Number: 117258 |
| Contact for further information | Julien Bouteloup, Founder/ CEO,:+44 7851456368, https://twitter.com/Flyingcarpeth, www.flyingcarpet.network |
| Long description | The Flyingcarpet network connects analytics-hungry businesses with a pool of data scientists who compete to create machine learning/artificial intelligence analytics-extraction models from visual data, such as drone and satellite imagery. The competition incentivization mechanism uses bounties on a live physical location heat map, and a Token-Curated Registry of Opportunities (TCRO) running on the Ethereum blockchain to collect and rank analytics-extraction opportunities. the Flyingcarpet network enables actionable insights through rich AI-powered analytics from insurance companies, and agri-companies, to governments. The Flyingcarpet utility token, Nitrogen (NTN), is used by data scientists to stake against the models that they create and used to stake against additions to the Token-Curated Registry of Opportunities (TCRO) - (Whitepaper).<br>The first PoC was completed in Papua New Guinea in 2017. Working with a local coconut farmer, Namaliu Jr., Flyingcarpet was tasked with assisting in predicting crop yields to better manage the harvest.<br>Flyingcarpet deployed an autonomous drone to survey the 100 hectare farm, using high definition video cameras. Once collected, machine learning/artificial intelligence analytics-extraction models were run on the collected visual data, and were able to provide an accurate survey of the coconut crop. This operation would otherwise have taken several workers multiple days to complete, and now allows Namaliu Jr. to better estimate his crop harvest returns and prevent theft of his coconuts.<br>“This groundbreaking proof of concept demonstrates just a fraction of the potential that AI-powered drones with blockchain technology can do to improvethe lives of people in emerging economies like Papua New Guinea, who typically do not have access to smartphones or the Internet,” stated Founder and CEO of Flyingcarpet Julien Bouteloup. “This is just one exciting use case for Flyingcarpet. The Flyingcarpet Network, and the machines which operate on it, have the potential to transform services across many industries, including the energy sector, infrastructure, logistics, as well as humanitarian efforts.”<br>The Flyingcarpet protocol which is a decentralized network, is used to deploy IoT devices including drones, to collect data in a timely and cost efficient manner. This network is used, especially when automating tasks that are otherwise expensive and labor intensive.<br>The Flyingcarpet protocol allows various stakeholders to benefit, including drone and drone charging station owners, developers who are rewarded in tokens for building machine learning applications for the network, as well as businesses and communities that employ the protocol to enhance their operations and reduce their costs. In this instance, a farmer could deploy renewable energy charging stations for drones to autonomously recharge their batteries, and continue their tasks. When a charging station is utilized, the owner of the device is rewarded with tokens.<br>Further to that, farmers who permit data collection on their property, could in-turn sell this data to businesses such as commodity traders trying to gain insights on harvest estimations. According to Viktor Tron, one of the first Ethereum Foundation employees and a Flyingcarpet advisor, “Julien and I share a common vision of fully decentralized supply chain economies. Drones are the future and the |

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| | Flyingcarpet project offers a decentralized solution to industries like agriculture and infrastructure. |
| Description of potential business benefits from blockchain use | Opening access to visual analytics-extraction machine learning models for everyone. Right now, machine learning models are locked away inside centralized analytics companies that sustain themselves by collecting intermediary fees.<br>Through Flyingcarpet data scientists capture 100% of the reward from their work, due to the aforementioned disintermediation.<br>Device owners also capture 100% of the reward from their data collection work.<br>Machine learning models are created via a competition of data scientists using a unique crypto economic incentive structure, which is a system that is made possible by our utility token.<br>Continued availability of past extracted analytics and machine learning models is not dependent on a centralized server, thus increasing long-term reliability. |
| Special concerns (legal, technical, etc.) | Drone usage regulation is a concern, because of the existence of varying regulations in different locations. However, due to the decentralized network of device owners, the responsibility for complying with these regulations therefore falls upon local device owners and not the Flyingcarpet Network. |
| Blockchain being used / proposed | Ethereum |
| Type of consensus algorithm used (if the blockchain is private or permissioned / consortium-based) | N/A |
| Rationale and trade offs considered when selecting a blockchain | The size of the community of users, extent to which the blockchain is decentralized (number of mining nodes), number of operational projects based on the blockchain, etc. |
| Any special hardware or other used (IoT, QR codes, etc.) | IoT (drones, static cameras, satellites) |
| Any open-source software being used / proposed | Ethereum (used), machine learning libraries (used), Truebit (used), Golem (used), FOAM (used), open-source Flyingcarpet machine learning base classifiers (proposed), entire Flyingcarpet codebase (proposed/already open-sourced) |
| Links to related information including technical white papers | Technical Whitepaper |
| Other | |

# Annex XVII: M-Akiba

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| Section / Sector | Section IX: Blockchain supporting the UN SDGs |
| Short description | |
| Proposing / Implementing / Testing Organization | Nairobi Securities Exchange Plc, Kenya and 55 Westlands Road, Nairobi |
| Contact for further information | David IrunguWaggema, Head of Enterprise Innovation & Project Management, dirungu@nse.co.ke, +254 728 370 772, @nsekenya, www.nse.co.ke; www.m-akiba.go.ke |
| Long description | M-Akiba is a retail bond issued by the Government of Kenya via the mobile phone platform. Akiba is a Swahili word meaning savings. Hence, M-Akiba stands for Mobile Savings.<br>M-Akiba was designed to address its key objectives, which are to:<br>1. Enhance financial inclusion for economic development;<br>2. Provide greater access & democratization of sovereign debt;<br>3. Provide funding for Government infrastructural development projects;<br>4. Promote the savings and investment culture; and<br>5. Drive a financial awareness campaign.<br>The account creation takes under 10 minutes as opposed to 3 – 21 days. The Issuer gets the funds on a daily basis as opposed to waiting for a month. The minimum investment is reduced to KES 3,000 i.e. approx. USD 30 or 25 Euros.<br>The M-Akiba model will be used for other security classes and as a way to eradicate poverty by making available bonds and securities to the retail market in a convenient, affordable way that adds value for all the various stakeholders. |
| Description of potential business benefits from blockchain use | 1. Having immutable records, doing away with a single central party as trust is automated amongst the partner organizations as well as increasing transparency.<br>2. KYC detail verification in countries outside Kenya but also for clients not having .<br>3. Configuring smart contracts for paying the interest/ coupon and redemption of the bond at maturity.<br>4. Tokenization of the bonds & securities as digital assets. |
| Special concerns (legal, technical, etc.) | These could include aspects ranging from the need for minimum response times, and the need for legal recognition, to the need for a minimum number of network nodes. |
| Blockchain being used / proposed | Oracle platform as a Service. Goland |
| Type of consensus algorithm used (if the blockchain is private or permissioned / consortium-based) | 75% consensus amongst the nodes in a round robin process is used where all nodes are trusted. To put it another way: A private permissioned Blockchain with preapproved nodes. |
| Rationale and trade offs considered when selecting a blockchain | Having a private blockchain that can be trusted |
| Any special hardware or other used (IoT, QR codes, etc.) | N/A |
| Any open-source software being used / proposed | Goland for smart contracts. |
| Links to related information including technical white papers | N/A |
| Other | |

# Annex XVIII: HashNET

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| Section / Sector | Section IX: Blockchain supporting the UN SDGs |
| Short description | HashNET is a scalable, fast, secure, and fair decentralized- beyond blockchain project, leveraging (DLT) and a consensus algorithm which keeps all positive characteristics of a blockchain technology. It is able to do all this, while also increasing throughput to more than 200,000 transactions per second. Network is using Proof-of-Stake with master-nodes, which eliminates the need for a massive energy consumption. |
| Proposing / Implementing / Testing Organization | HashNet Slovenia |
| Contact for further information | TadejSlapnik, Director, Tadej.slapnik@tolar.io, www.Tolar.io |
| Long description | HashNET has an asynchronous, gossip-based consensus mechanism that allows for lightning-fast processing of up to 200,000 transactions per second with low latency–(and a prototype already achieved 150,000 TPS on June 28th).<br>At regular intervals, the DAG representation gets consolidated in to a blockchain of strictly ordered transactions compressed with MimbleWimble technology. HashNET thus combines the advantages of a DAG-based asynchronous consensus mechanism, with those of a synchronous blockchain,(for example data structure of finalized transactions)but with a structure that is much smaller than a full blockchain, and can also be stored on a mobile phone.<br>In addition, Tolar includes an implementation of the Ethereum Virtual Machine with Solidity smart contracts. This makes it an ideal platform for ICOs which can deal with familiar technology while profiting from all the advantages that Tolar offers. |
| Description of potential business benefits from blockchain use | Since most applications of blockchain technology aim to provide transparency and indisputable records of transactions, it also has a great potential to eradicate corruption. With digital ledgers providing a secure channel for making and recording transactions, anything requiring verifiable and auditable transactions becomes automated. Instead of keeping ledgers in a central place, blockchains are then shared across networks encompassing as many users as are registered. Their ledgers keep growing as it records each transaction. |
| Special concerns (legal, technical, etc.) | Minimum masternode hardware requirements:<br>• quad core 64bitprocessor<br>• 16 GBRAM<br>• 128 GB of available diskspace<br>• Fixed and unique IP (only one masternode can run at one IPaddress) |
| Blockchain being used / proposed | TolarHashNET |
| Type of consensus algorithm used (if the blockchain is private or permissioned / consortium-based) | HashNETAsynchronous BFT consensus algorithm |
| Rationale and trade offs considered when selecting a blockchain | New development stage of blockchain, energy efficient, therefore corresponding indirectly to all SDGs, and directly to selected SDG12. |
| Any special hardware or other used (IoT, QR codes, etc.) | Solution for Quantuum resisting computing which will enable achievement of goals in efficient ways, and the use of all other special hardware (IoT, AI, …) will be enabled on the platform. |
| Any open-source software being used / proposed | TolarHashNet is open source distributed ledger technology by itself. |
| Links to related information including technical white papers | Tolar.io |
| Other | SDGs in focus: 8.9.11.12 |

# Annex XIX: Cherr.io

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| Section / Sector | Section IX: Blockchain supporting the UN SDGs |
| Short description | CHERR.IO is building the first fully transparent ecosystem for charitable causes, supported by Ethereum smart contracts, and fueled by the CHR token which puts the power into the hands of the people. Every single aspect of CHERR.IO will be governed by those willing to create a better future. |
| Proposing / Implementing / Testing Organization | CHERR.IO d.o.o., Slovenia, VAT: SI48659932, Company num: 8129029000 |
| Contact for further information | David Tacer, Co-funder, CEO, Development engineer, david@cherr.io, 38640221931, https://www.linkedin.com/in/davidtacer/, https://www.cherr.io/ |
| Long description | CHERR.IO (the solution) is a blockchain solution for charitable donations, aiming to open new horizons for the way charitable, humanitarian and socially responsible organizations operate. The platform will opt for optimizing operations, expand outreach, reinforce donors' trust and improve the donation process for charities. The top focus is fraud prevention and transparency. Alongside this the solution is aiming to enable decision power for donors and a reward system for active participants. The solution aims to raise funds with cryptocurrencies and thus, enable donors to experience low transaction fees.<br>CHERR.IO will use a gamification process to engage with a multitude of interested parties willing to both donate and volunteer for people in need. The opportunity to help and reap rewards is now open to the masses.<br>CHERR.IO ecosystem will be build from:<br>• Structured airdrops (Rewards for active participants)<br>• dApps (CharityMarketCap, CHERR.IO platform)<br>• Charity entities (From charities to nonprofit organizations and individuals as ambassadors)<br>• Donors (Expanding traditional donations to crypto community and making them transparent, safe and efficient)<br>• Token holders (Governance, Voting rights, Rating rights)<br>• Socially responsible companies (Companies with a yearly budget for donations)<br>• Virtual donors (Master-node partners) |
| Description of potential business benefits from blockchain use | Fraud prevention and increasing transparency in charity sector. |
| Special concerns (legal, technical, etc.) | Legal |
| Blockchain being used / proposed | Ethereum |
| Type of consensus algorithm used (if the blockchain is private or permissioned / consortium-based) | N/A |
| Rationale and trade offs considered when selecting a blockchain | N/A |
| Any special hardware or other used (IoT, QR codes, etc.) | N/A |
| Any open-source software being used / proposed | Solidity, Truffle, Node.js, web3.js, PHP |
| Links to related information including technical white papers | |
| Other | SDGs in focus: 2/ 3/ 4 |