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Technical Paper HSTP.DLT-UC

Distributed ledger technologies: Use cases

International Telecommunication Union

Summary

This technical paper approved by SG16 is based on the following deliverable of the ITU-T Focus Group on Application of Distributed Ledger Technology (FG DLT):

– Technical Report FG DLT D2.1 "Distributed ledger technology use cases"
https://www.itu.int/en/ITU-T/focusgroups/dlt/Documents/d21.zip

It consolidates each of the real-world use cases gathered during the lifetime of FG DLT.

The document also presents the knowledge extracted from these use cases, highlighting the competitive advantage brought by DLT to each use case, describing the main barriers to DLT adoption, and how new business models based on DLT can contribute to the attainment of the Sustainable Development Goals. Finally, it assesses how the use cases could benefit from a standardization effort.

The uses cases are classified into two domains: vertical and horizontal. Each domain has classifications and sub-classifications.

Tokens mentioned in this technical paper are only for the purpose of analysis of technical architecture and use cases. None of these tokens are endorsed, neither in their technical aspects nor as investments.

The use-cases featured in this technical paper were selected under pre-defined criteria defined by FG DLT as examples of possible good use of DLT to support the SDGs. The inclusion of a use-case example does not imply an endorsement of or judgment on the quality or applicability of the mentioned use-cases.

Keywords

DLT; distributed ledger technology; ledger; blockchain; use cases

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Distributed ledger technologies: Use cases

1 Scope

This technical paper approved by ITU-T SG16 consolidates the real-world use cases gathered during the lifetime of ITU-T Focus Group on Application of Distributed Ledger Technology (FG DLT).

All use cases gathered, classified and prioritized were selected based on pre-determined criteria developed by FG DLT.

Appendix I provides an overview of the use cases considered by the FG DLT. The electronic attachment to [ref-DLT-D2.1] contains additional details for each of the use cases.

Tokens mentioned in this technical paper are only for the purpose of analysis of technical architecture and use cases. None of these tokens are endorsed, neither in their technical aspects nor as investments.

The use-cases featured in this technical paper were selected under pre-defined criteria defined by FG DLT as examples of possible good use of DLT to support the SDGs. The inclusion of a use-case example does not imply an endorsement of or judgment on the quality or applicability of the mentioned use-cases.

2 References

All references relevant to this publication are found in the Bibliography hereinafter.

3 Definitions

This document uses DLT related terms defined in ITU-T Technical Specification FG DLT D1.1 [ref-DLT-D1.1].

4 Abbreviations

AML	Anti-money laundering
AR	Augmented reality
CBDC	Central bank digital currency
DAG	Directed acyclic graph
DAO	Decentralized autonomous organization
DDoS	Distributed denial of service
DL	Distributed ledger
DLT	Distributed ledger technology
DM	Data model
GDPR	General data protection regulation
GHG	Greenhouse gas
GPT	General purpose technology
ICO	Initial coin offering
ICT	Information and Communication Technology
IM	Information model

IoT	Internet of Things
IP	Intellectual property
IT	Information technology
KYC	Know your customer
LMC	Low-middle income country
MVP	Minimum viable product
NFT	Non-fungible token
PoC	Proof of concept
POS	Point of sale
PoW	Proof of work
ROI	Return on investment
SCADA	Supervisory control and data acquisition
SDG	Sustainable development goals
SLA	Service level agreements
TTP	Trusted third party
UI	User interface
UX	User experience
VAF	Value added feature
VNR	Voluntary national review
VR	Virtual reality

5 Introduction

This technical paper consolidates all the use cases gathered during the lifetime of the ITU-T Focus Group on Application of Distributed Ledger Technology (FG DLT). It presents information about applications and services based on distributed ledger technologies (DLT), submitted by organizations from around the world to the Focus Group between 2017 and July 2019. An emphasis is placed on the lessons learned by the contributors, hence, the Focus Group only considered use cases which have reached at least a proof of concept (PoC) stage as of July 2019.

This document consolidates the knowledge extracted from the use cases. It introduces the potential competitive advantage brought by DLT to applications and services. The use cases were categorized into vertical and horizontal domains, where the vertical domain includes applications and services enabled by DLT in the financial, healthcare, information and communication technology, entertainment, industrial, government and public sectors, while the horizontal domain covers services applicable across sectors, such as identity management, security and data management.

This paper also discusses the main barriers to DLT adoption, covering technical as well as non-technical barriers. It also outlines how new business models based on DLT can contribute to the attainment of the Sustainable Development Goals, and describes how the use cases collected could benefit from an international standardization effort.

Finally, this paper summarizes key findings, contributes key recommendations and offers a repository of all collected use cases in the appendix.

This paper was jointly written by volunteer specialists from various organizations representing public and private sectors, as well as academia and international organizations. It addresses a wide audience including policy makers, regulators, standards developers and technical communities.

The aim of this document is to assist interested parties in recognizing issues and priorities, to exchange information and best practices through peer learning and knowledge dissemination processes, and to identify possible policy interventions.

The competitive advantage of using DLT in applications and services

The benefits gained from the use of DLT vary by use-case, environment, event, process and industry. While the financial sector, for example, may make use of the crypto-currency features associated with DLT, other sectors may make use of other features of the technology, such as distribution, disintermediation and others. This clause looks at common threads that are effective in multiple use cases, as well as unique features that are more specific to certain applications.

5.1 General benefits

Common to many use-cases is the view that DLT is a secure, cost effective technology that enables the deployment of globally scalable services. It supports a multitude of disruptive innovations that can improve existing solutions and drive the development of new products and services. DLT is considered as a tamper-resistant and auditable technology that is resistant to systemic failures. It is also an effective tool to detect and mitigate fraud.

DLT can be seen as a form of general purpose technology (GPT). A GPT is a technology that on top of standing for itself – also brings gains to other technologies and sectors. It may take a long time to reach mass adoption, but once adopted GPT leads to productivity gains across multiple industries [ref-coa-1], [ref-coa-2], [ref-coa-3]. Classic examples of GPTs include the steam engine, electricity and the internet. DLT revolutionizes the way we look at data in terms of trust, anonymity, storage, and processing. Being in the information era, where "data is everything", DLT's innovative approach to handling information and its agnosticism to the types of data it handles, make it a useful tool in many fields of business, administration, research and government – thus the designation as a GPT.

5.2 Transparency and trust

DLT is perceived as a canonical trusted and transparent shared resource that makes interactions and transactions understandable, traceable, certifiable, and accountable.

The major beneficiaries would be use-cases that include untrusted stakeholders seeking to build a trusted infrastructure where data can be shared in a secure and accountable manner.

5.3 Security

There are multiple aspects of security that are related to DLT:

1. Encryption of data. DLT allows data to be easily encrypted, which can be useful to many use cases.
2. Access control. Albeit the fact that all records exist in many nodes of a DL, access to records can be restricted on a per-record-per-user basis.
3. Tamper-resistant data. Once data is loaded into a DL, it would require extensive computational resources and/or massive collusion amongst voting stakeholders to modify the DL without being noticed by others, hence rendering it practically immutable.
4. Identity management. Participants in a DL can be anonymous, pseudonymous, or fully identifiable.

5. Fault tolerance. DLT consensus algorithms offer a means of redundancy to mitigate the risk of the overarching network being compromised if one or more components of the DL network fails.

As a result of the above, DLT provides secure data provenance, which is crucial for data authenticity, forensics, and privacy. It has the potential to enhance privacy and secures consumers and businesses against theft or data manipulation, ensuring tamper-resistant records. DLT can play a significant role in fighting fraud and helps detect and fix incorrect bindings. DLT has shown the potential to function as an effective tool for the verification of identity information (without disclosing the underlying identity information itself).

5.4 Economic and social incentives

The economic incentives for the adoption of DLT vary depending on the use-case, with some benefiting from cost-reductions, new revenue streams, or both. Cost reduction is achieved through disintermediation and increased efficiency (discussed further in the coming paragraphs), while new revenue streams are generated through removal of technological and operational barriers, thus enabling new types of services or applications.

DLT enables near real-time disbursement of money directly to its designated recipients. This can be of value to any industry domain that transacts money, either as part of an application (e.g., payment for goods or services) or as means to transfer value (e.g., transfer money).

While the obvious method of disbursement of money using a DLT will be in the form of a cryptocurrency, DLT can also be used to store and operate on information while using non-cryptocurrencies to settle payments. The DLT may use an electronic version of an existing government issued, or "fiat", currency that is pegged to a certain fiat currency. For example, an "eUSD" will always be worth exactly 1 USD. Another scenario is a DLT that is not associated with a cryptocurrency at all and the payments happen using regular bank transactions (e.g., through an API to SWIFT transactions).

DLT enables more trustworthy decentralized applications with potential high social and public interest. Traceability of DLT based applications can serve to increase the safety of products (e.g., food) or circular economy applications.

DLT decentralization and identity management features can also serve to provide services with social impact, like eHealth or smart energy applications. It will also serve to increase the efficiency and accessibility of public services, like notarization, taxation and/or diplomas.

DLT enables fast on-line trading 24/7 and may serve to overcome regulatory and operational obstacles.

DLT offers further competitive advantages through reduction in the *cost of verification* and the *cost of networking* [ref-coa-4].

The *cost of verification* relates to the ability to verify attributes of a transaction at a lower cost than existing auditing intermediaries [ref-coa-5]. DLT is an assistive factor in the digitization and decentralization of processes, minimizing the trust necessary in a manual or centralized solution. In this way, DLT provides a tool of trust that minimizes (or eliminates) the need of an auditing intermediary as it enables real-time auditing.

The *cost of networking* represents the efforts required to bootstrap and operate a multi-stakeholder platform without need of an intermediary. Incentive systems may vary depending on the specific operational and commercial environment.

Architectural innovations, by the knowledge and assets incumbents have accumulated [ref-coa-6], open opportunities for entrants to reshape market structure. DLT allows platforms to operate with lower barriers to entry, enabling innovation. It also challenges existing business revenue models and

opens opportunities for new approaches to the provision of public goods, software protocols, data ownership, licensing, auctions and reputation systems.

5.5 Efficiency and reduction of complexity

It has been observed in multiple deployments that the use of DLT serves to reduce complexity and increase efficiency. It allows for better tracking of assets and transactions. It can serve to significantly shorten timelines and automate paperwork laden manual tasks thus making processes rapid and simple. This is achieved through removal of data silos and establishing direct, traceable and secure interactions between stakeholders.

DLT enables the creation of digital platforms where the benefits from network effects and shared digital infrastructure do not come at the cost of increased market power and data access by an intermediary. This reduction in the cost of networking has profound consequences for market structure, as it allows start-ups and open-source projects to directly compete with entrenched incumbents through the design of platforms where the rents from direct and indirect network effects are shared more widely among participants (e.g., developers, users, investors), and no single player has full control over the network.

While it may have more to do with artificial intelligence and big-data analytics, the ability to perform smart-contract operations based on data transacted in a DLT can serve to integrate the functionality of multiple disparate systems into a single system. DLT thus may serve as an accelerator for automation within organizations' IT departments, specifically in scenarios where automation of the ledger alone does not yield visible incentives. If, for example, the use of DLT allows you to shorten a certain part of a process from 24 hours to 5 minutes, but this process is part of a chain of events that took 90 days to complete, then shortening a 90 day process to a 89 day process does not yield visible gain. If, however, the use of DLT drives automation of other parts of this 90-day process and as a result it can be shortened to 7 days, then the overall gain is much more significant.

5.6 The benefits of disintermediation

Many supply-chain management operations rely on a centralized intermediation entity that handles the transactions across a large network of untrusting (often competing) stakeholders. Examples would be SWIFT bank transactions, SITA flight booking, Uber ride sharing, Airbnb private rentals, and others. Such intermediaries serve a crucial role in coordination between stakeholders and customers, increasing visibility of services to potential customers and enabling centralized transactions. The services offered by such coordinating entities are typically associated with a fee charged to the stakeholders (e.g., Uber keeps about a third of the fare charged to the customer) and managing visibility and control between stakeholders and the intermediating entity may be complex and difficult to achieve (e.g., mobile operators may have different rate plans for roaming visitors based on their home network operator). Through the use of DLT, the stakeholders can create a common interchange and enforcement mechanism without a trusted third party. Information exchange and visibility can be easily managed, and anonymity can be preserved where required.

Novel digital platforms, in absence of a central 'clearing house' or market maker, can benefit from permissionless innovation. As long as an application is compatible with the established protocol and consensus rules, it can be deployed on the network without permission from other participants. This reduces the expropriation risk application developers face when building on top of existing digital platforms (e.g., iOS, Facebook etc.). Furthermore, since each contributor to a DLT-based platform can theoretically shape its evolution in a way that is proportional to its stake in the platform (e.g., in terms of computing power, storage, labour or capital dedicated to it), these new platforms can democratically evolve over time to accommodate changes in market design that are beneficial to the majority of contributors.

5.7 Identity management

The process of identity verification is central to all economic transactions. A well-functioning market and economy relies on robust identity management to verify the goods and services being exchanged (e.g., in terms of their provenance, how they moved through the supply chain, etc.) and the credentials of the parties involved (e.g., degrees on a curriculum vitae, professional licensing status, bad actor status, driving record, etc.). Identity management is further discussed in clause 7.1.

6 Vertical domain

The vertical domain represents different sectors of the economy. Sectors considered by FG DLT were:

– Finance
– Healthcare
– Information and Communication Technology
– Entertainment: Arts, Culture and e-Sports
– Industries
– Government and Public Sector

6.1 Finance

Some of the most mature use cases of DLT have been in the financial services industry [ref-fin-1]. From the obvious use in financial payments (e.g., Bitcoin) to the more complicated use in trade settlement (e.g., Digital Assets partnership with ASX), the financial industry has been testing the technology since its early days. While some banks have gone ahead with developing the technology in-house (e.g., J.P. Morgan's Quorum), others have made strategic investments (Goldman's investment in Circle), and many have joined industry consortiums (R3 CEV) to engage with the technology and test the proof-of-concepts.

Considering the current system of financial markets, DLT could potentially address the following issues, and more:

– Time consuming and costly processes of reconciling information arising from data silos;
– Lack of trust between different stakeholders;
– Vulnerability to cyberattacks in centralized databases, including risk of large-scale compromises of data hosted by individual players;
– Situations where the user is not really the owner of their data;
– Processes not equipped for 24/7/365 operations where they should be.

Key benefits of DLT adoption for the finance sector include:

– Simplifying settlement and reconciliation across organizations;
– Removal of intermediaries from the value chain;
– The ability to implement atomic transactions;
– Trust enforced programmatically by design and tamper-proof audit trails;
– Increased transparency;
– Risk reduction as any transaction history (e.g., credit history) is an immutable part of the ledger;
– Fraud minimization;
– Compliance efficiency improvement through automation;
– Enabling more open, interoperable and programmable exchange platforms;

Nonetheless, there are still many barriers and issues that may hinder the DLT adoption in finance, which are discussed later in this document (see clause 7.1 for identity management and clause 8 for barriers).

Current financial markets systems are still largely centralized [ref-fin-2][ref-fin-3], with key central clearing and settlement agents around the world like Depository Trust & Clearing Corporation (equities), Chicago Mercantile Exchange (for commodities) and CLS Group (for foreign exchange). The financial services industry has also traditionally been regulated due to its importance in the overall economy.

At the same time, at least 40 central banks around the world are currently, or soon will be, researching and experimenting with central bank digital currency (CBDC) [ref-fin-4]. CBDC, a commonly proposed application of blockchain and distributed ledger technology (DLT), has attracted much interest within the central banking community for its potential to address long-standing challenges such as financial inclusion, payments efficiency, and both payment system operational and cyber resilience.

The subcategories for the classification of the use cases in the finance sector are listed in Table 1 below. The categories were initially inspired by Tapscott [ref-fin-5]:

Table 1 – How DLT can be applied to the subcategories

ID	Subcategories	How DLT can be applied
1	ID verification (KYC/AML)	DLTs can provide a trusted way to do customer verification to satisfy KYC (Know your Customer) and AML (Anti-Money Laundering) obligations, e.g., through past immutable data in the DLT.
2	Tokenization and stable coins	The digitization of regulated financial products and services such as security/asset tokens and utility tokens and create new ones, e.g., cryptocurrency/payment tokens through tokenisation.
3	Financial management (accounting and auditing)	Smart contracts can automate some accounting processes. Auditing costs can be reduced through cheaper verification of transactions in DLT [ref-coa-4].
4	Reduction in the risk of fraud	Real time data is decentralised, and this can increase trust of the shared data, e.g., management of cash or financial controls, data of maritime industry for insurance purposes, etc.
5	Funding	DLT creates new revenue opportunities such as new models of funding and new types of markets such as equity crowdfunding, secondary market or new types of exchanges.
6	Investments	Tokenised assets can support the transformation of the regular investments model and promote accessibility to new asset investments.
7	Regulatory compliance and audit	DLTs can provide accurate and tamper-proof financial, audit and regulatory reports thereby improving speed and quality.
8	Clearing and settlement	Automation and improvement of the centralized clearing and settlement processes using DLT can result in increased efficiency and reduction of costs, time and agents involved.
9	Payments and P2P transactions	DLTs can bring new models and arrangements to make payments and transfers faster with lower costs and less or no intermediaries. E.g., remodelling correspondent banking, cross-border payments, etc.
10	New product models	New peer-to-peer insurance models can be secured with DLT. Credit: Decentralised financing.

6.2 Healthcare

Health is defined as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" [ref-hea-001]. Working toward this end is a global, multi-sectorial effort. Healthcare has been recently added to the list of sectors, which could be disrupted by DLT in more than several ways.

DLT technological advancements in healthcare have been documented, among others, at the use of data to record and analyse the behaviour of individuals. This has become pervasive. The adoption of wearables and Internet of Things (IoT) connected devices has accelerated this expansion. Whether users consent to this analysis has been partially addressed by GDPR regulation in the EU, which requires transparency in the use of data.

In the health environment, data collection, recording and analysis is even more delicate since health data is considered as a special category of sensitive personal information. Health data is often organized into silos in order to preserve patients' data. However, silos contribute to information asymmetry, which generates both an imbalance in market competition to provide services and a lack of information sharing for proper patient diagnosis. This lack of information sharing results in slower diagnosis, more expensive testing, insecure data transmissions between silos and incomplete records [ref-hea-2].

In order to try to solve these problems, Akerlof [ref-hea-3] has suggested the concept of using DLT to make the patient the unique and exclusive owner of their medical data, thereby reducing the number of examinations, procedures, and overall costs incurred. Interoperability is fundamental to support this patient-centric model which would allow for greater security while decreasing the need for trust between service providers [ref-hea-3].

In this context, DLT technology has emerged as a path to application development that enables interoperability between systems by securing reliable information [ref-hea-4] [ref-hea-5].

DLT is decentralized, secure, and reliable. These attributes make it well suited to self-sovereign health data interoperability needs though special considerations must be made for governing privacy on the DLT [ref-hea-6] [ref-hea-7].

Examples of relevant use cases are defined for the following areas of healthcare: pharma, biotechnology, medicine, and insurance [ref-hea-8] [ref-hea-9] [ref-hea-10].

6.2.1 Pharma

The global pharmaceutical industry was valued at USD 934.8 billion in 2017. Pharmaceutical industry participants spend millions on patents that can be worth billions of dollars. Tracking these extremely valuable patents is one application DLT is well suited to.

Furthermore, pharmaceutical companies often receive government funding to produce specific drugs, such as vaccines and autoimmune diseases. Both the movement of monies from government coffers to companies and the movement of medical commodities through the supply chain are areas where DLT is well suited. In 2020, according to the World Health Organization (WHO), counterfeit medicines cost the world economy more than USD 75 million. Tracking the provenance of medicines using DLT is one approach to reducing this trade in counterfeit medicines [ref-hea-11].

DLT can help by providing better transparency and traceability for payments and products. For example, to obtain more accurate and trustworthy information for supply chain management when companies have to register their products in the private system to ensure authenticity and the high quality of their medicines. This is particularly important in the supply of medicines that must be kept in controlled environments, such as vaccines that require cold storage. This DLT-based approach to supply chain management can even be extended to materials (e.g., active pharmaceutical ingredients (API), excipients, containers) long before they reach the manufacturing facility.

While the literature portrays opportunities for DLT in the pharmaceutical industry, there are still significant hurdles to overcome before DLT can achieve wide adoption. Many of these use cases are at the proof-of-concept stage and require further testing [ref-hea-11].

6.2.2 Biotechnology

Biotechnology is the science of applying technology to biology in order to alter living cells to make them work in a more desirable way. The biotechnology industry performs genetic research to develop pharmaceuticals, medical devices and other products for human diseases, medical conditions and public health.

Since biotechnology firms use sensitive genetic data and material in their work, it reasons that data integrity, privacy and access control are paramount to collaboration. The decentralized and encrypted nature of DLT offers the potential to increase trustworthiness amongst participants and co-researchers, while enabling a tamper-proof audit trail for patent information [ref-hea-12] [ref-hea-13].

6.2.3 Medical records

Despite numerous standards, health records remain fragmented and difficult for patients to move from provider to provider. The interoperability of medical data can improve the way a diagnosis is made and better define patient treatment. Focusing on data management and interoperability of different health systems will increase the accuracy of EHRs (Electronic Health Records) [ref-hea-14].

Healthcare services are shifting to a more patient-centred approach. Health systems, based on DLT, could increase the safety and reliability of patient data since patients retain control over their health records. These systems can also help consolidate patient data by allowing the exchange of medical records at different health care institutions. The storage of medical data of patients is very important in healthcare. This data is very sensitive and therefore also a primary target for cyber-attacks. It is important to protect all sensitive data. Since access to a patient's health records could be governed by the patient themselves, there would no longer be a central point of attack that could be compromised to release large numbers of patient records. Therefore, DLT has the potential to provide a resilient framework for the management of health data. DLTs provide the infrastructure which may enable users in the future to have more control over their health histories and medical records, allowing for better decision making and preventative measures to be applied [ref-hea-15].

6.2.4 Fraud prevention in the healthcare system

Today, fraud in the healthcare industry is difficult to police. Two primary use cases are worth discussing. First, fraudsters will solicit treatment for an ailment more than once. For example, they may attempt to fill a valid opioid prescription at several different medical establishments. Since there is no "universal source of truth" on whether the patient has received treatment, the fraudster can "double spend". With DLT, the treatment is written to the DLT and all providers that are part of the network can request access to the patient's health records before providing treatment. A second form of fraud occurs where fraudsters claim a disability with the government based on an illness or injury. Similarly, the government agency providing aid can require access to the fraudsters' health records in order to provide assistance. In the current environment, many of these cases of fraud successfully pass through routine control for long periods [ref-hea-16] [ref-hea-17]. A third form of fraud is falsified certification of healthcare professionals (e.g., licenses, diplomas, qualifications).

There are not many studies detailing how DLT can be deployed in the fight against fraud. However, the use of smart contracts with transparent rules can introduce compliance by design and help discourage, and discover, fraud as it occurs [ref-hea-15] [ref-hea-17] [ref-hea-18].

6.3 Information and communication technology (ICT)

While traditional centralized management of data has proven to be a functional, fast, and efficient fit for many scenarios, there are certain cases where DLT offers features that may be of benefit in the ICT industry.

Current DLT deployments in ICT can be broadly divided into three main categories[1]:

a) Retail services

b) Wholesale services

c) Internet of Things (IoT)

While services from these categories may involve multiple ICT providers, the differentiating factors are related to the users of the services, the types of services and the beneficiaries from the use of DLT.

6.3.1 Retail services

Retail services are services where the end-user (typically mobile or fixed-line subscriber) would be the main beneficiary of the service. DLT is used to enable new services and service features that were not available prior to its deployment. Also, existing services offered by mobile operators that may benefit from DLT include mobile top-up, touch/scan-to-pay and mobile payments.

DLT enables such services to be offered to visiting/roaming customers from other networks and for its own customers when they visit/roam other networks [ref-ict-1]. Both can be broadly categorized as opening up mobile-operator services that were previously available only to its full-time subscribers while on their home network, to visiting users from other networks and to its own users roaming to other networks.

Another popular use case is establishing a marketplace [ref-ict-2] where vendors (or government offices) sign up with ICT which enables the selling and purchasing of goods (or payment for services) through applications installed on their ICT devices.

Looking into the future, IoT will heavily depend on efficient, fast and low-cost data transfer, processing and security.

The inherent ability of DLT to handle both data and payments reduces the complexity of data exchanges, including digital monetary transactions, which involve multiple players. It does so by providing an incorruptible underlying ledger infrastructure that reduces the number of systems involved, removes data silos and establishes trust between stakeholders.

While traditional centralized management of data may be a good, fast and efficient fit for many scenarios, there are certain cases where DLT offers features that may be of benefit in the ICT industry.

6.3.2 Wholesale services

Wholesale services are services where the ICT operators are the main beneficiaries of the services. ICT operators live in a state of *mutual-suspicion* and in an environment of "*coopetition*" where ICT providers both compete and cooperate with each other on delivery of services. On one hand, ICT operators compete with each other by trying to win the consumer business. On the other hand, ICT operators often rely on complementing their own portfolio with certain elements of service that they acquire from their competitors. This could be geographical coverage of a certain territory, computational or storage resources, specific applications or security features not available through the ICT provider's own resources.

[1] The authors believe that these subcategories may not be exhaustive in covering all ICT use cases.

Management of a supply chain in an environment of mutual-suspicion and coopetition precludes the option of using a centralized intermediator. It is unlikely that ICT providers will be willing to offer a third-party visibility and management of their resources.

The wholesale ICT industry is therefore based on a mesh of bilateral agreements between ICT operators transacting in an equal-level playing field.

Being a distributed and non-hierarchical ledger, DLT is a good fit for wholesale ICT supply chain scenarios even when the ultimate beneficiary is an individual subscriber and the supply chain includes operators, cloud, application developers, on-line stores, points of sale (POS) and banks. DLT allows all stakeholders to be linked together to ensure trusted transactions take place and information is correctly stored and retrieved by all parties. Some examples are reviewed below.

Consider number porting as an example where DLT can offer benefits over a traditional centralized database.

Today, it is quite common for a mobile subscriber to have switched from their original operator to a second, or even a third operator, while still keeping the telephone number that they were originally allocated. If their number is 054-123-4567 (where 054 represents the dialling prefix of the original operator) the whole number is required to be ported to the new operator.

When someone dials that number, the 054 prefix automatically routes to the original service provider. The original service provider needs to somehow verify whether that number is still on their network before routing it to the correct new service provider, typically for at least some cost.

For efficiency, it makes sense for all operators to keep a database of ported numbers so that when one of their subscribers dials 054-123-4567, they will route the call directly to the new operator. The question that arises is how such a database is managed and kept up to date.

One option would be to use a traditional database managed centrally. It would be difficult to define which operator, or neutral third party, would have the responsibility to manage that database and to agree who would pay the cost of operating and administering this database.

The fact of the matter is that today each mobile operator pays a monthly check to one of several third-party companies that manage and administer such databases. In return, the mobile operator is able to query that database prior to routing each call. If the dialled number is found to be ported, the operator is able to route the call to the correct operator.

However, if we were to use DLT as a number porting database technology, then each mobile operator would be able to run their own ledger of ported numbers. Within a set of pre-defined rules, each operator would have access to update the DLT with the ported numbers on its network. Through the automatic replication of data across all nodes, this information as well as information updates from other mobile operators reflecting the ported numbers on their respective networks would rapidly be available at each DLT instance on each mobile operator's own systems.

The end result would not be different from using a centralized database except that the information would now be available locally and would not require a monthly check to be paid to any third-party database operator.

In another example [ref-ict-3], a group of ICT partners successfully demonstrated a proof of concept that makes use of DLT, artificial intelligence and machine learning with the potential to disrupt the international wholesale voice minute settlement process and dramatically reduce inter-carrier dispute settlement times.

The initiative demonstrated a significant reduction in the time and effort required to identify discrepancies, resolve disputes and generate undisputed invoices for financial settlements by analysing and settling a whole month's worth of wholesale voice traffic between two major European carriers within less than 4 minutes.

Put into perspective, this process is currently performed manually and typically requires 6 weeks of work from as many as 30 employees at each operator to complete.

Another example could be the maintenance of a global repository of network resources through a distributed federated catalogue [ref-ict-4]. This DLT database could be used to speed up the process of inquiry, ordering, maintenance, invoicing and settlement of network resources including connectivity, compute and storage on-demand across two or more ICT operators' networks.

In October 2018, a team of 8 ICT operators and 2 technology partners joined forces to demonstrate the ability to perform an inquiry, quote and an order across a chain of multiple interconnected ICT operators all within less than one minute. Additionally, the proof of concept demonstrated the ability to invoice, reconcile SLAs and make settlements, including financial transactions, across the same chain of ICT operators within less than two minutes. Both of these processes typically take weeks of work using manual processes.

6.3.3 IoT

IoT, or Internet of Things, is a fast-growing field of technology that involves a wide range of devices (hence "Things") producing data that needs to be collected, analysed and stored. IoT involves aspects of connectivity as some devices may not be physically connected to a network. It also involves aspects of security to prevent data manipulation and aspects of size, power demand, and computation power. It is beyond the scope of this document to address all those aspects and, as this is a fast-growing technology, there are still many unknowns. One significant aspect of this technology related to DLT is the frequency and volume of information produced by IoT devices and the resulting DLT resources required to process such information. The current transactional capabilities of DLT platforms seem to indicate an effective balance between on-chain and off-chain data storage will be essential for IoT to benefit long-term from DLT and new methods of data collection and transaction processing will need to be developed to meet those needs.

6.4 Entertainment: Art, culture and e-sports

As with other domains, the arts, culture and eSports domains benefit from business process enhancements that derive from new distributed and decentralized business models.

According to UNESCO, [ref-ent-1] the entertainment sector is worth USD 2,250 billion and provides nearly 30 million jobs worldwide. The sector generates new sets of asset classes both online and in real life that are highly valuable and tradeable. In the US alone, Over the Top (OTT) video revenue is worth USD 16.4 billion and eSports market revenue is worth USD 281 million while traditional cinema box office earnings are worth USD 11.1 billion [ref-ent-2].

6.4.1 Art, design and culture domains

In the art, design and culture domain, DLTs serve as an emerging medium and material for artistic creation and production (crypto-native-artefacts, materialized coins, design experiments and performances with smart contracts, mining rigs as hardware sculptures and objects) probing the promises, fears and expectations about the future infrastructure and medium of exchange. They explore the aesthetic, political and social implications of new digital objects and their interaction with existing artistic artefacts: sculptures, land art installations, conceptual art strategies, etc.

6.4.1.1 Crypto-native-artefacts as art assets, installations and performances

Artists are exploring various ways of materializing tokens, hashes and smart contracts by embedding them with unique characteristics. Examples include coins/tokens stamped with the blood of the artist or hashes of coins sold as light art installation objects (Kevin Abosch), mining algorithms and rings materialized as artistic hardware or sculptures and embedded in traditional art objects (Bittercoin, Bitcoin of Things, painting frames "Untitled Mining Installation"). Smart contracts are also interpreted as artistic performances with non-human actors or land art installations (ecosystem DLT

self-management in Terra0, Plantoid sculpture reproduction using Ethereum donations, Lithopia land art contracts with satellites).

6.4.1.2 Crypto-collectibles, puzzles, rare objects and cryptoart

DLTs support so-called rare digital artworks ("rares") or trading cards with unique non-fungible tokens (NFTs) supporting the idea of digital scarcity (CryptoKitties, CryptoPunks, Dada.nyc, SuperRare, Tarasca). DLTs can also facilitate a form of murals as puzzles that reveal a code for some cryptocurrency prize (Pascal Boyart).

6.4.1.3 Supporting co-op models for artistic creation

Artists and activists explore the potential of DLTs to enable co-ownership, artistic cryptocurrency and co-ops in various domains (music, art, tangible and intangible objects).

6.4.1.4 Decentralization and fragmentation of ownership and new art markets

DLTs allow art objects to be digitally fragmented and offered as shares in artworks which support new forms of art auctioning but also co-ownership of artworks and collections. These solutions also support new forms of authentication, documentation, licensing, tracking and management services for artworks in existing art markets, and/or create new art marketplaces (Verisart, Artory, Bidpoc, Ascribe, Portion, Maecenas, Codex Protocol) [ref-ent-6].

6.4.1.5 Contracting and payments to performers, production staff, and others

Many workers in the arts and entertainment industries operate on a freelance or per-gig basis. DLTs can streamline contracting, payment and employment records with any number of DLT-based notarization tools. Micro-payments and lump sum payments can be facilitated via cryptocurrency wallets, exchanges and platforms. Smart contracts can be used to automate these payments the moment specific requirements are met.

6.4.1.6 Credential wallet for professional qualifications, experience and other data

Professional qualifications and records of experience (Myceliaformusic.com, Musicwontstop.com) allow for performers and creatives to track their collaborations and create a record or passport of their career and achievements. Collating professional achievements in this way facilitates reputation management, charting networks, collaborations and guest performances in the real-world ecosystem of professional arts practice. Benefits go beyond recorded artefacts in the digitized realm. Alternative implementations may stem from other verticals including health passports where physical health may be important (elite performers) and facilitating swift visa arrangements where performers hail from diverse backgrounds and nationalities (Federation Internationale des Acteurs, Dance Passport [ref-ent-7]).

6.4.1.7 Traceability, attribution, and royalties

Archive and attribution records in the performing arts (music, dance, art in the public realm) are important to culture and community. Browsable digital archives that co-exist with and complement the living archives of performers' bodies are vital to documenting the artistic achievements of an individual, a company, and a genre or art form sub-group. Many performers document their work digitally and these artefacts take various forms: text, image, video, augmented reality (AR) / virtual reality (VR), movement analysis, and sensor data. This digitized data may be usefully repurposed and included in archive and attribution records.

In addition, there is a cohort of creators who share performative output across social channels (e.g., B-boys use Instagram to share new moves and challenge rivals prior to competitions or other events). Many creators object to their creative output being re-purposed, re-used, and/or monetized without attribution, permission, or their knowledge.

Where digital artefacts of performances are available, ownership and royalties due can be asserted via DLT (Soundac). It is worth noting that existing systems are poor at tracking and collecting royalty payments on the part of creators [ref-ent-8].

6.4.1.8 Performance on digital decentralized platforms

Given the context of IP theft and the fair concern with copyright and income protection on the part of creatives, there is a growth in DLT-based online performance outlets. A number of new streaming platforms facilitate alternative performance opportunities with direct payment to creators.

This represents a new audience reach for creators within competitive art forms, freestyle dance, hip-hop music as well as traditional arts where cultural expression is handed down from body to body by informal means. Examples of these DLT use cases include video streaming on DLT (Dlive), music streaming on DLT (Bitsong.io, Voise.com) and movie distribution on DLT (Breaker) [ref-ent-9]. Decentralized live streaming has relevance to the eSports and gaming communities too, where gaming is a performed entertainment.

6.4.2 eSports

eSports is a form of competition using video games. It primarily takes in the form of organized, multi-player video game competitions, between individuals or groups. eSports and games were the pioneers in the use of virtual currencies, known as gold-farming [ref-ent-10]. Hence, the use of existing games https://papers.ssrn.com/sol3/papers.cfm?abstract_id=294828on new GPTs (e.g., DLT, blockchain) is met with fewer barriers to entry [ref-ent-17] than other traditional industries with stricter regulations, like banking and finance. This allows for faster adoption [ref-ent-14].

The unique thing about gaming lies in the users. Users do not need to be strongly incentivised to download and play a new game. As long as the game is well marketed and appears somewhat entertaining, up to 2.2 billion gamers worldwide are willing to try, and half of them are even paying money to do so [ref-ent-11].

Aside from the ease of adopting virtual currency in the industry, DLT brings about other benefits, such as cross-gaming tokens that can be used across multiple games and/or game distributors. Five other specific examples are elaborated below.

6.4.2.1 Hosting decentralized tournaments for non-elite players

Previously, only a handful of elite players could compete for the prize pools associated with tournaments, pushing smaller players out of the game. Now, DLT based tournaments allow players to run their own small peer-to-peer tournaments [ref-ent-15]. Amateur players or newer players can participate, test their skills, and bet on games without being dependent on traditional money transfers, financial regulations, and the corruption of bookies and middlemen. The platform creates a system that allows gamers and companies the chance to create pools and offer prizes in a secure way through smart contracts [ref-ent-12].

6.4.2.2 Reputation management

eSports can also include reputation management mechanisms. DLT provides decentralized and scalable computing resources to augment developers' infrastructure and provide mechanisms to mitigate cheating, downtime, and costly maintenance that would be a result of using traditional means.

6.4.2.3 Community involvement and rewards

eSports involve an ecosystem where users are encouraged to create guides and video tutorials to help other gamers improve their skills [ref-ent-13]. Contributors of high-quality content are generally rewarded with tokens, which may then be used to access other services within the platform. In DLT

systems, token holders will also be able to liquidate their tokens to fiat currencies or use cross-gaming tokens within the ecosystem to access other games [ref-ent-17].

6.4.2.4 Facilitate betting and increasing security

Betting is an extremely popular by-product of eSports tournaments and accounts for a good deal of income in the space. For example, the NFL brought in USD 13 billion in 2017 while NFL fantasy leagues and betting brought in more than USD 50 billion [ref-ent-18]. DLT creates a trustless, secure ecosystem for low fee betting outside the control of a central party. This opens up the possibility of gambling to a whole new audience – as any who were once hesitant or fearful of getting involved because of skewed odds, can now do so with their mind at ease since contracts are fully auditable. The use of the tech makes it significantly more difficult to fix match results and get away with it due to the way it logs and remembers every transaction of all participants across the network [ref-ent-16].

6.4.2.5 Reduce forgery

The sale of gamer-earned goods is a huge source of contention in the gaming industry, with payment often being forged and people sometimes being conned out of their hard-earned reward. Use of DLT can certainly be employed here to increase trust and reliability when it comes to making money out of the time and effort spent playing a game [ref-ent-14]. DLT simplifies payments like these by automating payments when checkpoints are reached, creating a genuine, secure means of income for gaming enthusiasts [ref-ent-17].

6.5 Industries

DLT provides a way to record and transfer data that is transparent, safe, auditable and resistant to outages. It has the promising ability to transfer the organizations that use it into a transparent, decentralized, efficient and secure system by tweaking DLT components according to industry-specific requirements. Although the products and services vary across different industry sectors, many of them open similar opportunities such as multi-party data exchange, coordination of logistics, automated payments and contracts, auditing and compliance requirements, etc. DTL can provide viable solutions for cost efficient information, operational and financial management. Furthermore, many industry use cases deal with physical information that needs to be collected using IoT devices for better accuracy and efficiency during data collection.

Several major industrial sub-categories are identified and briefly described below. It is worth highlighting that other clauses of this document (i.e., ICT, entertainment, finance and healthcare sectors) could also be classified as industries but the editors decided to dedicate separate clauses to those topics.

– Supply chain: a consortium of stakeholders in a supply chain can own, operate and enforce trading rules and payment terms for their own shared ledger while keeping records integrated and reliable [ref-ind-1].

– Energy: DLT shows increasing promise for securing SCADA systems in traditional energy grids while enabling distributed energy generators such as rooftop solar panels and electric-vehicle charging stations to access cheaper peer to peer energy transfers [ref-ind-2].

– Transportation: DTL provides tamper-proof traceable records, simplified claim settlement, automated payment transactions as well as transparent price and ownership information throughout the entire process [ref-ind-3].

– Agriculture: DLT can be used to log data throughout the entire process in food production including lot of origin, quality and safety controls which improve food supply chain traceability, while simultaneously enabling efficient and fair payment solutions for farmers, distributors etc. [ref-ind-4].

– Forecasting: centralized prediction markets deal with substantial sums of data and little insight on their prediction models which puts users at risk of tampered information. DLT can create alternative decentralized business models minimizing the risk of counterparty risk and providing automated pay-outs. Some examples include political polling, weather services, company forecasts and event hedging [ref-ind-5].

– Human resources: DLT can store tamper-proof information including full employment history of employees (or the hash of the personal information for protection of personal privacy) and relevant activities of legal entities [ref-ind-6].

– Digital marketing: some solutions are using DLT to tokenize people's attention where the user may be paid to receive marketing information [ref-ind-7].

– Loyalty programs: Loyalty programs have relied on virtual assets for a long time. Customers collect points that can be traded for other products according to rules set by the merchant. DLT may be employed to decentralize the custody of loyalty programs and promote open exchange of points for other assets [ref-ind-8].

– Environment: DLT enables the transition to cleaner and more efficient decentralized systems, peer-to-peer trading of resources or permits, supply-chain transparency and management, new financing models for environment outcomes and the realization of non-financial value and natural capital [ref-ind-9].

The following two sub-clauses describe supply chain and the climate industry in greater depth. Supply chain was chosen because it is fundamental for all industry sectors and there are continuous R&D efforts and expenses allocated to optimize supply chains to reduce friction and improve efficiency. The climate industry, on the other hand, is a nascent but crucial component of any industrial sector as environmental impacts are counted as key valuation factors for sustainable development of businesses, industrial sectors, and the economies of countries.

6.5.1 Supply chain management

Supply chain management involves the efficient creation and distribution of goods which can be an extremely complex process. Depending on the product, the process can span hundreds of stages, multiple geographical locations (some cross borders), a number of payments and various individuals and entities. The whole process can take months to complete. Low efficiency results in extra operational expenses across the supply chain and these inefficiencies and costs increase as the supply chain grows.

Supply chain is about the efficient management of flows of goods, data and money. The key requirements are reliability and integrity which are strengths of DLTs. The distributed consensus-based nature of DLT lends itself well to dispute resolution in supply chains since all entities on the chain have access to independently verified versions of the ledger. Every participant on the DLT can see (depending on permission scheme) the custody and ownership for an asset and the tamper-proof chain of events that led to the current state of that asset. By adding IoT sensor-based data, supply chain architects can further enhance the quality of data entering their DLT. Several early DLT-based supply chain applications are deployed in the following sectors: manufacturing, agriculture, industrial goods, international e-commerce and mining among others.

– Agriculture supply chain

  Challenges in agriculture supply chain include disconnected stakeholders, limited financing resources, lack of transparency, costly middlemen and more. DLT can be employed to trace and track the farming, food processing and production, distribution and retail process and provide an unaltered record of food provenance. The IBM Food Trust initiative [ref-ind-4] started with their collaboration with Walmart and has grown into a global consortium that includes big name companies such as Dole, Driscoll's, Kroger, Nestle, Tyson and Unilever. The

improved data traceability provided by the IBM platform reduced the time it took to trace a mango from the store back to its source from 7 days to 2.2 seconds [ref-ind-10]. That reduction in time enables companies to identify contaminated supply chains and recall affected products before they are consumed and cause illness.

– International e-commerce supply chain

  Traceability and transparency are some of the most important foundations of logistics, especially the international supply chain, where goods are transported across borders and involve extensive time for shipping, customs, inspections, etc. DLT enables data to be simultaneously updated for multiple stakeholders. In international trading and transactions, overall efficiency can be greatly improved. Chinese e-commerce monolith Alibaba, recently announced that it had successfully integrated DLT technology into the company's cross-border logistics business. According to the company, its DLT-based system keeps track of all relevant information regarding an imported shipment, including details about production, transport method, customs, inspections, and third-party verification [ref-ind-11].

– Mining industry

  DLTs are leveraged by a consortia of mining companies as transfer of custody registry to increase audit efficiencies and transparency in the metals mining industry, a USD 1.8 trillion market [ref-ind-24]. Initiatives are underway such as Responsible Gold Ecosystem to record data on brand, origin, custody and location of precious and rare-earth metals in distributed ledgers, as means to curb illicit sales and related crimes [ref-ind-25] [ref-ind-26]. The digitization of mining supply chains can provide an aggregated real-time view of transactions and data flowing through the supply chain. Some solutions allow various levels of permissioning of both read and write data, as required by industry participants, auditors and consumers.

6.5.2 Climate industry

Confronted with the perils of an accelerated change in the climate, the need has arisen to adjust and rethink our current market structure and approach to economic growth. From what has been observed, a significant transition is occurring, not only in the global market but also in the means of production [ref-ind-12]. This new logic is built on the observed reality that growth and development cannot be detached from environmental concerns and sustainability.

Against this backdrop, a new logic of production has emerged responding to the need for climate solutions. This emerging green economy is based on the concept of a "climate-conscious industry," where the costs of environmental externalities connected to sustainability are incorporated into pricing and then directed toward efforts to mitigate and adapt to climate change.

Recently, a new call from the scientific community indicated the "traditional" approach to addressing climate change is not enough. A new collective effort and considerable technological investment is needed to achieve the necessary levels of reduction of greenhouse gases (GHGs) and limit the impact to the environment. To address these new calls, a number of businesses in the nascent "climate industry" have turned to innovative, and sometimes technologically intensive, business models. Currently, it is possible to identify many climate related initiatives relying on emerging and disruptive technologies, such as Artificial Intelligence, Internet of Things, and Distributed Ledger Technology (DLT). This technological turn taken by certain players in the climate industry has the potential to enable an increased level of decentralized access to climate solutions but it is important for the energy demands of these new technologies to be considered before implementation. There exist today a number of start-ups and other small and medium actors taking steps to revolutionize business models of the existing climate industry, each with significant potential to contribute to the overall green economy.

As for industries covered, the climate industry and its DLT variations cover a wide array of sectors. As seen in the Internet era, where processes slowly and then very rapidly migrated to digital systems, nearly every traditional industry may 'convert' to a DLT climate variation by leveraging the technology to address key pain points where trust is lacking between participants in existing processes. Despite this broad array of possibilities, there are already some sectors that are spearheading this process of 'conversion' by offering innovative solutions and somehow disrupting the "traditional" climate approach [ref-ind-13].

To better understand these pioneering initiatives, it would be useful to cluster them into groups by assembling them according to their objectives. The main clusters to date are: Energy Substitution (CarbonX [ref-ind-14], SolarCoin [ref-ind-15]); Resource Efficiency (Energy Blockchain [ref-ind-16]); Decentralized Funding (Moeda Seeds [ref-ind-17], Carbon Coin [ref-ind-18]); Offsets Tracking (Poseidon [ref-ind-19]); Networking and Marketplaces (Power Ledger [ref-ind-20], Nori [ref-ind-21]); and Supply Chain (Everledger [ref-ind-22], BVRIO Institute [ref-ind-23]).

6.6 Government and public sector

Incomplete and inconsistent quality data makes effective decision making extremely difficult, especially in government. The lack of digitization aggravates the problem. With many records scattered across multiple departments and even existing only in paper form, people need to appear in person to register, update and retrieve their information and certificates. Even in governments with a high level of digitization, DLT can be used to prevent forgery and counterfeiting by presenting trusted data.

Governments also regularly work with individual private agencies, all of which have their own collection of data and information management protocols. These non-transparent, fragmented systems may create mismatched and scattered data that is difficult to weave together. Governments are also not allowed to access sensitive information from individual private agencies. Government services, therefore, require duplication. Evaluation of successful programs becomes difficult, tax dollars go uncollected, infrastructure maintenance becomes inefficient and health care dollars often go to waste. Even when the government implements data analytics to help make better decisions, the analytics are only as good as the data itself.

DLT could simplify the management of trusted information thereby making it easier for government agencies to access and use critical public-sector data while maintaining the security of this information [ref-gov-1]. Over the last couple of years, governments started experimenting with DLT for the purpose of increasing accountability, transparency and efficiency for government affairs. There are a number of DLT tools and technologies that government agencies can implement today to protect critical data and improve the management of records associated with property ownership and incorporation. In the long term, as DLT matures, governments may also use it to enable networked public services.

Currently, applications of DLT in government and public sector can be broadly categorized into:

a) Regulatory compliance

b) Government data management

c) International relations

d) Digital evidence proof

6.6.1 Regulatory compliance

Compliance with regulations is a promising area for governments to use DLT to boost efficiency by eliminating some of the intermediaries. Regulatory compliance usually involves several intermediaries and steps. Having a shared ledger implies a shared data format. This should make it easier for regulators to aggregate the information they receive and turn it into meaningful insights.

All of this would give regulators a far richer, more accurate and timely view of the state of markets or supply chains at any given time. This could contribute to public safety while reducing fraud. With real-time data in financial markets, for instance, governments could spot trouble at a bank or insurance company much more quickly than in the past and potentially take proactive measures to ring-fence it. This would allow them to intervene more quickly and accurately in the event of product recalls or public advisories. Such systems could also be useful in monitoring critical infrastructure like energy or air traffic, allowing for more efficient oversight but also intervention in an emergency. Governments could also better monitor dangerous goods, like chemicals or firearms, by having a much clearer picture of where they are and how they are used. This too could contribute to improved public safety [ref-gov-2] [ref-gov-3].

6.6.2 Government data management

DLT enables a transparent, decentralized, digital network that could help governments effectively collect and store data, not only to improve the data management process, but also to bring more trust in government through DLT. One of the most important functions for DLT in government is around the verification of records and sharing of data of various kinds, which refer to identity, title/asset registration, healthcare, educational certification, e-voting, etc. A more secure infrastructure like the DLT network can decrease inefficiencies of older systems and gain greater trust and adoption by the wider public. Over time, with a DL network, the government can create rules and algorithms that automatically share data and assets with third parties once the parties fulfil the smart contract's terms. These smart contracts remove the need for additional human resources as well, which can be costly and time consumptive [ref-gov-1] [ref-gov-4] [ref-gov-5].

The Once-Only Principle (OOP) needs to be seen in the context of public sector digitization. This means that citizens and businesses provide diverse data only once when in contact with public administrations while public administration bodies take actions to internally share and reuse this data, even across borders, with respect to data protection regulations and other constraints. The concept of OOP focuses on reducing administrative burden for individuals and businesses by re-organizing public sector internal processes. European Union countries have started to implement this principle for the eGovernment Action Plan 2016-2020 [ref-gov-15] and is part of several initiatives related to the European Digital Single Market. Currently, there are two projects SCOOP4C [ref-gov-16] and TOOP [ref-gov-17] under this.

Table 2 gives a summary on different DLT applications governments adopted in their trials.

Table 2 – Summary of government DLT applications

Use Case	EU [ref-gov-6]	Dubai	New Zealand	China	Korea	US [ref-gov-12]
Government database	✓		✓ [ref-gov-9]			✓
Law	✓			✓ [ref-gov-8]		✓
Tax	✓ [ref-gov-15]			✓ [ref-gov-7]		
Citizen identity	✓	✓ [ref-gov-11]			✓ [ref-gov-10]	
Residency		✓				
Land registration	✓	✓				

6.6.3 International relations

International relations is the field in which actors from different countries interact with one another on a daily basis [ref-gov-13]. DLT can be used as a tool to promote integration and cooperation between states, especially within multilateral arrangements. To promote cooperation, smart contracts can be used to increase the credibility of the enforcement of agreements where states can put value in a smart contract's custody to prove their commitment. The parts of the agreements need to show that they are really acting as agreed. However, if the necessary data to control the agreement is not managed by DLT, there should be a way to receive it from the external world in a trustable way. To promote integration, DLT can be seen as a way to share and manage information among states in real-time, without intermediaries and without reconciliations. In fact, a shared ledger preserves state autonomy while promoting more efficient business relations.

In the context of international security, one important use case is gun control in a global scale. Transparency and accountability are not often present in arms transactions which favours diversion and the appropriation of weapons by criminal actors or non-state combatants. A proper use of the technology regarding record-keeping, managing arms stockpiles and transfers could became instrumental for identifying points of diversion, trafficking routes, embargo and sanctions violations among other illegal activities [ref-gov-14].

In sum, the technology could provide new and innovative solutions to old hurdles in multilateral systems. Transparency, accountability and commitment are among necessary features for international interaction and DLT applications could strengthen them greatly.

Enabling free flow of digital assets, censorship-resistance transactions and new ways of governance are also benefits that can create a long-term impact to existing international relations that, at the same time, open new issues.

6.6.4 Digital evidence proof

Digital evidence or electronic evidence is any probative information stored or transmitted in digital form that a party to a court case may use at trial. Most of the countries have legally accept digital evidence to be a kind of legal evidence on the court. Digital evidence includes for example, e-mails, digital photographs, ATM transaction logs, word processing documents, instant message histories, files saved from accounting programs, spreadsheets, internet browser histories, databases, the contents of computer memory, computer backups, computer printouts, Global Positioning System tracks, logs from a hotel's electronic door locks, and digital video or audio files. DLT technology can be used to provide proof and temper-resilient validation of digital evidence signed in a specified instant of time.

7 Horizontal domain

As an emerging technology, DLT has the potential to be applied in many areas, not only for vertical use cases, but also throughout horizontal domains. The horizontal domain represents use cases that are applicable across multiple sectors of the economy.

Considering the actual use of DLT and the collection of use cases, the following sub-categories were identified and are further described in the following sub-clauses: identity management, security management, data management, governance and DAOs and crypto-infrastructure.

7.1 Identity management

A DLT-based digital identity solution could focus on three key challenges: security, privacy, and portability. DLT technology may offer a way to solve this problem with or without the need for a trusted central authority. More specifically, individuals and businesses could store and authenticate their identity on the DLT, giving them greater control over who has their personal information and how they access it. By using a decentralized, open-source DLT and combining it with an identity

management tool, we could create a digital ID which would act as an incorruptible watermark. This watermark could be used to verify an identity for any transaction in real time. Once such a digital ID has been created, it could be used to verify an identity for any service and dispense with the need for clumsy and unreliable password/I combinations [ref-hor-1].

Scenarios may include securing medical records of patients, credit assessments of bank customers, access-management systems in secured locations and many others. DLT can associate features and attributes to an individual without revealing the individual's identity. It can be used to prevent identity theft without risking leaks of sensitive information to prying eyes. Besides, an identity is inextricably linked to its assets. Traditional identity systems are cost ineffective, fragmented and inadequate in the face of sophisticated attacks. They limit the ability of financial institutions to provide a seamless transaction experience. Thus, deploying robust and modern digital identity systems is the next step to establish the true digital identity of individuals, companies, and assets [ref-hor-2].

7.2 Security management

Security management is the identification of an organization's assets (including people, buildings, machines, systems, and information assets) followed by the development, documentation and implementation of policies and procedures for protecting these assets. An organization uses such security management procedures as asset and information classification, threat assessment, risk assessment and risk analysis to identify threats, categories assets, and rate system vulnerabilities so that they can implement effective controls.

DLT might play across the "CIA triad" of confidentiality, integrity and availability; offering improved resilience, encryption, auditing and transparency. For example, DLT has the potential to enable safer IoT device networking including the prevention of DdoS attacks [ref-hor-3].

7.3 Data management

Certain DLT implementations contain what everyone in data management, from data scientists to chief data officers (CDO), wants; information that comes with complete provenance. This is data which shows who did what, when and with a full tamper-proof history from day one verified by all parties participating in the network using the latest cryptography.

DLTs are authenticated records of the history of a network's activity distributed among the nodes of the network. DLT enables secure storage of arbitrary information (which, in some cases is a token balance and in other systems, more complex information) within the network simply by securing a set of private keys. After some years of evolution, DLTs are now capable of storing arbitrary data and establishing permissions to modify that data through self-administering and self-executing scripts which are performed by a distributed virtual machine. These scripts are known as smart contracts and they allow platform operators to define complex and fully customizable rules which govern the DLT's interaction with its users.

7.4 Governance and DAOs

DLT can be used to create new tools to realize governance for a decentralized global public utility for self-sovereign identity on the internet, for which a new term has been put forward, Decentralized Autonomous Organizations, or DAOs. A DAO is digital entity that manages assets and operates autonomously in a decentralized system but also relies on individuals tasked to perform certain functions that the automaton itself cannot. DAOs have automation at the centre and humans at the edges [ref-hor-4].

A DAO is similar to a regular corporation in that it is a separate entity and has its own bank account (here it is cryptocurrency wallet) and ID number (the contact address). The main difference is that a DAO is autonomous. In contrast to regular corporations, a DAO is managed by itself (its code) rather than by humans (in the form of executive management, i.e., CEO) [ref-hor-5]. The benefit here is that it is a public offering and open for everyone so that it gives equal rights to all token holders, brings

in more liquidity and makes it easier to buy and sell stocks. DAOs give the organization a high level of transparency which means little opportunity for corruption and less administrative costs.

7.5 Crypto infrastructure

The number of crypto-assets issued and traded now exceeds 1800 with a total market capitalization of more than USD 200 billion [ref-hor-6]. Behind this, a group of people are silently laying the groundwork for long-term crypto infrastructure including individual block producers, pools of block producers, BaaS (Blockchain as a Service) providers, wallets, and exchanges.

Concretely speaking, individual block producers and pools of block producers provide consensus services that maintain network security for the DLT, BaaS provides cloud-like infrastructure to applications, wallets help users to hold crypto-assets in hardware or software both online and offline while exchanges provide trading platforms for the circulation of crypto-assets.

8 Barriers to DLT adoption

8.1 General technological risks

8.1.1 Foundational technology versus legacy infrastructure

As a general foundational technology, DLT serves as the underlying infrastructural layer to interact with existing applications built upon it. Legacy infrastructure and methods that have been in place for decades are one of the major barriers to adoption.

The cost of overhauling or replacing the legacy systems currently used by large industries such as the financial, insurance and identity sectors is enormous. There is a significant investment of both time (education, training and tacit knowledge) and capital (equipment, software, affiliated applications, foundational technology itself and opportunity cost) to create a new infrastructure, train staff with the necessary skillsets and use it effectively throughout an organization [ref-bar-2].

The transition from legacy systems to DLT will be gradual and may take years to complete, thus there is an additional cost and complexity of integrating the new and legacy technologies and maintaining both platforms operable and interoperable [ref-bar-10].

8.1.2 Trilemma trade-offs

DLT platforms can offer decentralization, scalability and security. However, only two out of the three goals can be effectively achieved simultaneously. When applying a DLT based solution to a use-case, one faces the trade-off trilemma of which goal to prioritize. This trade-off may reduce willingness to adopt a DLT-based solution.

Security issues are flaws within DLT networks causing a significant impact to users. For example, while ownership of a private key can empower user control over data, loss of an account's private key can result in the permanent loss of access to the data stored at that account address.

Scalability issues may create throughput and processing speed bottlenecks affected by the consensus mechanism, number of nodes and network performance. Many applications, specifically crypto-currency related transactions, must be able to process transactions at certain rates and the ability to deliver such performance remains a huge barrier for adoption [ref-bar-3].

Decentralization allows disintermediation and autonomous operation without a centralized entity. However, decentralization requires governance through stringent and resource-consuming consensus mechanisms and potentially creates security risks where nodes use outdated or hacked code.

8.1.3 Lack of standards

To date, there are no widely accepted standards and interoperability requirements between various DLT platforms and the networks that operate them [ref-bar-3]. DLT applications are siloed and do not follow a unified approach to architecture, software design and interoperability.

8.1.4 Data security

Public DLTs pose a data security concern [ref-bar-4]. Depending on regulation and application, it may be impossible or illegal to store certain types of data on an unencrypted public DLT. Storing encrypted private data on a public DLT is costly and still raises security concerns (e.g., information cannot be re-hashed by changing a compromised key/password). Emerging encryption technologies, zero-knowledge proofs and multi-party computation may resolve this problem once matured [ref-bar-2]. Safeguarding data integrity and ensuring strong encryption mechanisms are perceived as key [ref-bar-12].

8.1.5 Failure points remain

Bitcoin (BTC) users tend to use exchanges to convert fiat to BTC and vice-versa and wallet software to facilitate transactions; both of which take on responsibilities akin to 'trusted third parties' and are therefore susceptible to fraudulent behaviour. A case in point was Tokyo-based Mt Gox, an exchange which at one point in 2013 was handling over 70% of all bitcoin transactions. In early 2014, Mt Gox [ref-bar-6] filed for bankruptcy protection and announced USD 450 million worth of bitcoins (BTC850k) were lost. As of the date of this document, only 24% of those lost coins had been recovered [ref-bar-6].

8.1.6 Return on investment (ROI) cycle

Due to hesitant and slow adoption by users, DLT projects typically demonstrate a slower ROI compared to other emerging technologies. Considering a finite pool of funds, investment in DLT is less attractive in the short term.

Investing in digital disruption can be expensive. The uncertainty regarding the ROI of new technology is a significant barrier to adoption [ref-bar-14] [ref-bar-15] [ref-bar-16].

Additionally, DLT demonstrates the greatest return on investment when different industry participants cooperate in the creation of a shared platform. Building a platform to only serve a single entity or company brings little commercial and operational benefits [ref-bar-8].

8.1.7 Potential high cost to implement

The potential high costs of initial implementation, perceived risks associated with early adoption of DLT and the possibility of disrupting existing practices may pose significant challenges to businesses [ref-bar-12].

8.1.8 Privacy risks

Privacy risks will require constant attention. Even if DLTs could be deployed to share data across public networks, they would still need to ensure that current and future encryption methods are strong enough to maintain user privacy. Potential security vulnerabilities and concerns about data privacy are significant challenges, particularly if users are entrusting DLT solutions with personal data [ref-bar-12].

Legislators, governments and regulators should develop legislation and regulations that address the benefits and challenges introduced by DLT. Examples of legal and regulatory implications of DLT would be the use of DLT audit trails as evidence in court, treating the code within a smart-contract as legally binding and mandating the use of DLT in certain scenarios [ref-bar-7].

8.2 Knowledge risks

8.2.1 Education: General DLT knowledge

DLT is a wide and complex environment that may be difficult to understand both from a technology perspective and from the potential business value perspective. On one hand, it is often presumed that "a problem can be solved by throwing blockchain on it". On the other hand, it is just as often that complex systems that could benefit from the use of DLT do not adopt the technology due to lack of knowledge or understanding of it.

The chasm typically lies between the DLT developers, who understand the technology very well but lack understanding of the business and operational requirements, and the business owners, who understand the business but are not aware where DLT can bring value. Mutual education is key for success, i.e., educating business owners and decision makers on the potential value of DLT and educating the technology vendors on the challenges of the users and markets.

Most companies do not have a DLT-skilled workforce. The vast majority of DLT projects are outsourced to an external resource that are skilled in DLT. Gaining DLT skills, either through education of staff or through acquisition of DLT-knowledgeable staff may bridge the chasm but may be difficult to justify commercially. The knowledge required to make decisions, implement the appropriate DLT platform and design the ecosystem is vast and complex. It requires time and energy to be educated and gain the required skillsets for participants on the ecosystem: developers, project managers, investors, engineers, economists, researchers, etc.

8.2.2 Education: Specific knowledge (DLT vs cryptocurrencies vs tokens)

Understanding the difference between DLT, cryptocurrencies and tokens is a key barrier in the space. Most decision makers believe that the terms are interchangeable and thus not applicable to their business use-case. While DLT is the foundational technology, cryptocurrencies are just one specific application that can be built on top of it. Tokens have many functions including but not limited to cryptocurrencies. Some projects do not even need tokens to leverage the benefits of DLT [ref-bar-8] [ref-bar-12].

8.2.3 Bad reputation: Fraud and hacks

The ability to transfer monetary funds without need of a bank or physical handling of cash has led to the use of DLT for illegal online trade of drugs and vices, known as Silk Road [ref-bar-2]. Bitcoin's decentralized pseudo-anonymous nature may make it susceptible to illicit transactions. At a certain point in time over 70% of the products traded on Silk Road were reported as illegal. The negative connotation caused a substantial effort to deter the adoption of DLT. With KYC/AML increasing at on- and off-ramps and the rise of companies like ChainAlysis, the extent of illegal transactions have reduced over time, but the negative connotation has been slow to dissipate.

The wave of DLT start-up projects and their associated fund-raising, either through an Initial Coin Offering (ICO) or through traditional Venture Capitalist (VC) funds, was accompanied by a plethora of scams and hacks that have raised credibility issues and created confusion among investors and public and contributed to the mistrust of the technology.

Digital hacks of crypto-FIAT exchanges remain commonplace since exchanges are a centralized, user-friendly place to store different cryptocurrencies. As the technology has matured, flaws have been found in the code of smart contracts and exploited by hackers. Major hacks include the DAO hack and parity multi-signature wallet attack on the Ethereum network, which have proven difficult for the respective communities to recover from [ref-bar-4].

8.2.4 Implementation know-how

The emergence of multiple non-interoperable DLT implementations has led to a fragmented ecosystem and is limiting widespread adoption [ref-bar-12]. The DLT ecosystem is fragmented in areas of focus of research, development and application. This results in a fragmentation of knowledge to specific platforms, requiring individuals to attain a substantial level of understanding and expertise to implement DLT-based solutions.

The implementation requires a multidisciplinary knowledge, skillset and approach such as choosing an appropriate DLT platform, selecting and on-boarding partners, educating the participants, economics design of the system and governance design.

8.2.5 Little experience related to decentralized governance mechanisms

The nascent nature of the technology yields a lack of clarity regarding the governance of DLT systems [ref-bar-12]. As DLT focuses on decentralization, the emerging trend of "decentralized governance" becomes a crucial mechanism. Compared to legacy centralized systems, DLTs are now governed by some of or all the participants in the network. This changes the method of governance and incentive mechanisms. Given the limited experience of such governance, it remains a key barrier to DLT adoption.

8.3 Ecosystem barriers

8.3.1 Dominant DLT platform: Permissioned vs permissionless platform struggle

As mentioned in clause 8.1.1, DLT requires a significant investment of time and money. Many companies are waiting for dominant platforms and applications to emerge prior to making an investment.

DLT platforms differ in privacy (private DLT vs public DLT), in consensus mechanism (Ethereum, Hyperledger Fabric, Corda, Bitcoin, EOS and many others), permission- or permissionless. Certain implementations offer inter-chain interoperability and hybrid platforms exist where a main chain provides public permissionless consensus for a network of permissioned and permissionless chains on top of it, such as Ardor. It is challenging to assess the quality of available solutions and determine the best way to integrate them within existing IT landscapes.

8.3.2 Many alternative solutions

There may be more than one solution to real problems [ref-bar-4]. Be it traditional machine learning, deep-tech, innovate tech, etc. DLT is just one of the possible solutions and even in the DLT ecosystem there may be more than one way to solve a specific problem. With a wide range of choices, coupled with the education and knowledge transfer of the alternatives, decisions take time and DLT is not always considered the best solution for the specific problem. Sometimes, the traditional centralized solution would be a better choice.

8.3.3 Interoperability: Separate DLTs not working together

While they are all DLTs, separate platforms and protocols do not seamlessly speak to each other [ref-bar-3]. Some DLT platforms are trying to resolve this using side-chains and alternative methods like atomic swaps. This remains a barrier to adoption albeit the evolution of inter-chain interoperability [ref-bar-4].

8.3.4 Underdeveloped front-end

As with other applications, the front-end defines the ease of use of a product. A complicated mobile app or website makes it difficult to navigate thus people do not use them. Similarly, the UI and UX of DLT applications are still being developed as the technology and backend matures. This makes it extremely challenging for non-technical people to use and adopt DLT applications.

8.3.5 Lack of supporting infrastructure

In order to fully adopt a DLT-based platform into a business, the supporting infrastructure must be developed. The introduction of digital identities and payment gateways are currently being developed and explored together with legal infrastructure and international standards.

8.3.6 Disintermediation

DLT helps to increase efficiency in the network by removing intermediators. Adopting the new technology may eliminate or reduce the role of intermediator third parties in the value chain. These intermediators include credit bureaus, banks, processors, security services, consultants, associations, clearing houses and other entities built around the need to provide guidance, services and assurance to ecosystems and industries.

Adopting a DLT solution will likely involve business process redesign that may change the roles and hierarchies within an organization which may affect existing employees acting as intermediators between departments or functionalities.

It would not come as a surprise that intermediators may feel threatened by the introduction of DLT-based platforms that may reduce, or even completely eliminate, their roles.

8.3.7 Credibility of DLT providers

While certain ICT giants have introduced DLT into their portfolio, many DLT providers are start-ups that may still be seeking investment and whose financial stability and product roadmaps are uncertain. IT and procurement departments may find difficulty identifying partners and vendors with longevity and stability that will see projects through to implementation.

8.4 Intrinsic features

8.4.1 Ability to bring networks together

Adopting a DLT may be complex enough for a single organization that is managed centrally. It becomes more complex when introducing DLT to a multi-entity environment that is not centrally managed (e.g., wholesale supply chain) [ref-bar-8].

When developing multi-entity DLTs, consortia would typically be formed. In some cases (e.g., wholesale telecom services) consortia may already exist for other purposes and may help drive adoption. All parties who want to transact must agree on the platform of choice and on data formats and processes to be followed. This may be challenging due to the lack of trust between parties (who may otherwise be competitors), disintermediation, lack of interest to join and the required investment in time and capital. Depending on the case, the risks can be too daunting to adopt DLT [ref-bar-3].

8.4.2 Intellectual property concerns

Intellectual property is an issue that should not be ignored. The challenge is magnified when public DLTs or multi-entity DLTs are involved. Private information is being shared on a public or a consortium network. Sensitive business logic and key programming functionality that is normally kept proprietary may now be exposed to others. Most IP concerns can be addressed one way or the other but would pose a barrier to adoption in certain cases.

8.4.3 Immutability

The software development industry uses agile development methods based on iterations of failures and corrections. When developing smart contracts on an operational DLT, the luxury of being able to correct a failure may not exist. Immutable records generated by faulty code cannot be deleted.

Lengthy PoCs or development in a lab environment may eliminate most of the faults but make smart contracts expensive to develop and become "flawless" [ref-bar-2].

8.4.4 Difficulties in upgrading and evolving large DLT platforms

It is difficult to upgrade large DLT platforms. There may be too much at stake and too much to lose. Decentralized systems have to get consent of all participants to upgrade the platform. Simple tasks such as introduction of new privacy and scalability features may be far more complex compared to centralized systems. Risks include drop-out rate, participants' unwillingness to move, etc.

8.4.5 New forms of cyberattacks

Though DLT is still a relatively new technology, platforms have already suffered various forms of cyberattacks [ref-bar-4]. Such attacks are not limited to the obvious public/permissionless DLTs but may also occur in private/permissioned DLTs.

8.4.6 High demand of energy

The distributed nature of DLT systems and the need for increased computing power for certain consensus protocols (e.g., proof of work, PoW) result in high energy consumption and the associated costs such as cooling, generating and conveying energy [ref-bar-12].

There is a risk that countries with sources of low-cost energy and cooling will dominate the PoW networks. This contradicts the decentralized nature of DLT.

8.5 Legal considerations

Heterogeneous legal regulation in different jurisdictions and missing legal certainty are a major barrier to the adoption of DLT. This has been shown in a survey where 23% named the lack of clear legal and policy frameworks governing DLT applications as a main concern [ref-bar-11]. The ITU-T Technical Report FG DLT D4.1 gives more details on existing and upcoming regulation such as privacy laws, financial regulation and legal liability [ref-DLT-D4.1].

8.5.1 Regulations

Legal and regulatory concerns around data privacy, intellectual property, enforceability of contracts, and choice of jurisdiction are inhibiting the technology's adoption.

Regulatory risk is inherent for disruptive technologies. Although Eastern regulators have taken a relatively strict line on cryptocurrencies, the looser stance in the West means that on balance the regulatory climate is relatively benign [ref-bar-3]. Regulations still remain one of the top concerns for businesses to adopt the technology in the next three to five years [ref-bar-9].

8.5.2 Knowledge gap of legal agents

Smart contracts are enforceable on the DLT platform. However, when issues arise, the smart contract can be brought to a judge to resolve the dispute. Given the nascent nature of the technology, the judge can have a knowledge gap in the reading and understanding of smart contracts.

An expert can be brought in to validate the information, which increases the time spent and cost of resolution. There is also a level of uncertainty in the knowledge of the domain knowledge expert in DLT (as opposed to other domain experts like forensic handwriting expert) and how the judge will digest the knowledge to give a verdict.

8.5.3 Regulatory uncertainty

One prominent barrier in the area of legal considerations is the uncertainty. DLT started with the philosophy of no governance and as the technology and adoption grew, governance has become needed. The concern over the lack of clear legal and policy frameworks governing DLT applications is a main concern for over 23% surveyed [ref-bar-11].

However, as everything is new, constantly changing and still emerging, the regulators are unsure of ways to govern DLT ecosystems.

8.6 Summary

The barriers to adoption can be categorized in five areas: technological risks, knowledge risks, ecosystem barriers, intrinsic features and legal barriers.

In general, the barriers are due to the usual nature of any new and emerging technology. The operating environment is too uncertain and risks are too high. That being said, with time, the risks and uncertainty should mellow out and encourage true adoption in the space.

The change in underlying technology (e.g., legacy systems to DLT) requires a significant investment in time and funds. To mitigate that risk, many legacy businesses are choosing to wait and decide when the time is right, leaving the door open for innovative new entities to lead.

9 Significance of DLT in the attainment of the Sustainable Development Goals (SDGs)

In September 2015, 193 members of the United Nations endorsed 17 Sustainable Development Goals (SDGs) to be attained by 2030. The SDGs provide a common and agreed framework to advance the world's future by resolving our most pressing sustainability issues. The task of attaining these goals and meeting their targets is a responsibility of each member state of the United Nations. Yet, to reach these goals, DLT offers an opportunity not only to work together across sectors (private, countries and civil societies) but also to innovate in finding new solutions for pressing global problems. Transformation towards sustainability is where DLT-based applications could be an extremely important enabling technology.

The advantage of aligning DLT technologies with the SDGs allows for easy monitoring of progress. The 17 goals hold over 160 specific targets and not less importantly, measurable indicators [ref-SDG-1].

The SDGs are perhaps the most ambitious and far-reaching initiative in human history to address major economic, social and environmental problems confronting our planet. The SDGs are predicated on the notion that efforts to alleviate poverty have to go hand-in-hand with endeavours that simultaneously seek to build economic growth while addressing a range of social needs including education, health and employment opportunities, while tackling climate change and environmental protection. Connectivity, internet and digital solutions are essential for successfully achieving nearly all the SDGs [ref-SDG-2].

One of the alarming challenges of the SDGs is the funding gap between all of the multilateral funding organizations and the financial requirement needed to fund the SDGs. Initial estimates suggest that achieving the SDG targets would require annual incremental investments of between USD 5 to 7 trillion [ref-SDG-3]. Enriching the resources to fund SDG attainment through never before available borderless (crypto) currencies is already in progress.

Far from merely tweeting or taking and sharing photos or videos, DLT enables an entirely new economic structure [ref-SDG-4] and ethically-minded solutions could lead to greater accountability and responsibility also around human rights and environmental impact.

However, DLT technologies are not a one-size-fits-all solution to these challenges but rather a key piece of the puzzle. Thus, two key questions this document tries to answer are: why and where do DLTs appear to add value resulting in better solutions for SDG attainment than current approaches?

Figure 1 – Sustainable Development Goals (SDGs)

The Blockchain Commission for Sustainable Development released a white paper entitled "*The Future is Decentralized: Blockchains, distributed ledgers, and the future of sustainable development*", which examined "six areas of application – development aid effectiveness, digital identity, remittances, supply chain management, energy and property rights" [ref-SDG-5].

The key features and general benefits of DLT described in clause 6 of this document can be leveraged in the attainment of all 17 SDGs.

The advent of blockchain and DLT bring with them new opportunities to democratize trust and augment top-down systems of regulatory enforcement. DLT empowers individuals to build and maintain bottom-up trust among themselves and to ensure all transacting parties adhere to an agreed set of rules. This autonomous property of DLT is a new power that allows individuals to gain assurance in transaction systems without relying solely on the proper functioning regulatory bodies and the proper scope of regulations. DLT technologies can establish automated distributed trust in systems whose rules are enforced by transparent operations, cryptography and distributed consensus agreement mechanisms. Development of new products and services based on emerging DLT technologies can benefit from clear guidance from regulators. This guidance should be based on an agile regulatory framework that supports small innovative businesses and avoids over-regulation that might stifle innovation and growth. These principles are now being considered with a new perspective; the extent to which DLT technologies can support faster (and better) attainment of the 17 SDGs. The need for such consideration is based on the results of Voluntary National Reviews (VNRs) demonstrating the gap in meeting SDG targets across the goals [ref-SDG -6].

Recently, several internal UN initiatives emerged with the objective of increasing understanding of DLT and information sharing tools across agencies and other UN bodies. The UN Innovations Network is spearheading such an effort out of New York and in Geneva. The importance given to early adoption of DLT technologies in the diverse United Nations family of organizations, funds and bureaus is emphasized by emerging projects in the field, development of policy and standardization, earmarked funding and solicitation of expertise, and it was expected that 2019 could see substantial integration of DLT at the UN [ref-SDG -7].

Table 3 presents an analysis of the potential utilization of DLTs for each of the 17 SDGs against select key global challenges highlighted by respective SDGs.

Table 3 – DLT solutions for key challenges [ref-SDG-8] in the 17 SDGs

SDG #	Challenge	Solution (one example)	Example FG DLT use cases
1	One in ten people in Low-Middle-Income Countries (LMCs) are living with their families on less than the international poverty line of USD 1.90 per day.	DLT can automatically record transactions on a secure ledger with near-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 address 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.	HLC-004
2	Not all people (and especially children) have access to sufficient and nutritious food all year round.	DLT could strengthen the supply side, particularly for small-scale food producers and family farmers, thus enabling them to better access markets and receive equal treatment in the supply chain.	IND-005 IND-007
3	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.	DLT can support enhanced prevention and treatment outcomes through, for example, breaking down data silos across medical providers and enabling the tokenization and incentivization of physically or mentally beneficial activities.	HLC-002 HLC-003 HLC-005 HLC-006
4	Access to inclusive education	DLT-based platforms could connect students, educators, and service providers where, together, they develop and engage in personal and group online sessions, as well as in-person educational programs where progress, attendance, and completion are automatically tracked.	GOV-006
5	Discrimination against women and girls globally	DLT could help women earn and retain control over additional income. DLT also has the potential to mitigate on-line harassment.	IDM-002
6	Clean water is an essential resource for life, yet its distribution is globally unbalanced.	DLT combined with IoT sensors enables households, industries, water managers, and policymakers to all access the same data on water quality and quantity in order to make more informed decisions.	
7	Increasing the share of renewable energy and doubling the efficiency of energy production.	DLT enables the ability to tokenize energy trading platforms, allowing consumers to trade the energy from solar panels and batteries in a peer-to-peer network, incentivizing the introduction of new devices to local microgrids.	IND-002
8	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 with an	DLT can allow the sale of small value mobile retail bonds and promote inclusive growth in an economy by democratizing sovereign debt.	GOV-001 FIN-004 FIN-006

SDG #	Challenge	Solution (one example)	Example FG DLT use cases
	emphasis on the emerging middle class because the really poor have no money to invest at all.		
9	Economic development	Trading with a DLT-based regulatory-compliant global currency can enable micro-transactions which are an important enabler of services and particularly services tailored for the poor.	FIN-004
10	Reducing inequalities in the economy, governance, rights and decision making.	DLT can enable better economic equality by reducing the costs of remittances. It can also open new avenues for citizens to get involved in decision-making through secure voting initiatives.	GOV-003 FIN-007
11	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	DLT can provide a cost effective and trustworthy enhancement for local democracy within cities, allowing neighbourhoods and large housing developments, to have a voice, through voting, on decisions that affect them.	GOV-003
12	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.	Tracing of products in supply chains relates closely to consumers awareness of the origins of products, sustainable production methods, and health implications.	IND-005 IND-006 IND-007
13	Challenges to the ability of the world to meet climate change goals, creating the risk of irreversible ecological disaster	DLT can 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, DLT platforms for trading assets which represent carbon could guarantee immutability and transparency.	IND-004
14	Protect marine and coastal ecosystems from pollution, as well as address the impacts of ocean acidification and other negative practices such as over-fishing.	DLT can combat overfishing and wildlife trafficking by providing the baseline architecture for interoperable data collection, allowing better management of ecosystems, more informed decision making across organizations, and increased accountability around catch types and quantities since competing organizations must share the same ledger.	IND-011
15	Reversing the effects of land degradation and desertification through sustainable land management	DLT can 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.	GOV-002 FIN-007

SDG #	Challenge	Solution (one example)	Example FG DLT use cases
16	Strengthening the rule of law is the fundamental key for success in this process of achieving peace.	Smart contracts executed on DLT platforms can be used to automate and enforce agreements between business entities.	GOV-004
17	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	DLT can be used to facilitate 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 DLT can support the empowerment and capacity building of communities and regions on both the domestic and international level.	GOV-002

The use-cases in this document's appendix highlight examples at and beyond the PoC phase, from which we identify with the following conclusion.

Meeting the SDGs will require experimentation and innovation, leveraging 'whole of government' approaches that cut across silos, bringing about shared understandings of interlinkages and tradeoffs between various goals and highlighting major pain points for interventions. DLT can accelerate and amplify attainment efforts because it is relatively quick to develop and relatively easy to adapt to such a wide range of tasks since it is conducive to enabling processes amongst multiple stakeholders. Energy requirements and externalities of DLT platforms require close examination in the context of picking optimal tools for addressing SDGs.

10 Standardization efforts

"*Standards facilitate interoperability: this is important for competition. Furthermore, by setting ground rules, common terminology, development methods, and measurement techniques, standards enable the development of follow-up innovations and the diffusion of innovations.*

Standardization may also help create critical mass in the formative stages of a given market. However, setting standards can also pose risks: they may lead to undesirable lock-in into sub-optimal technologies and allow incumbents to create barriers to market entry with negative implications for innovation." (Source: https://www.innovationpolicyplatform.org/content/markets-competition-and-standards)

Standardization can provide "economies of scale" benefits and ensure effective interoperability between different systems and platforms. It also provides the conditions to avoid anti-competitive behaviours and to efficiently conduct market operations. Nevertheless, there are concerns regarding an overly prescriptive approach that could prevent innovation at this early stage of DLT maturity.

Taking an abstract approach, a DLT use case can be broken down to two abstract layers: the ledger layer and the applications layers. The ledger layer is based on either open-source ledgers, downloadable from public repositories such as github.com, or on proprietary ledgers developed by individual developers/vendors. One may ask if standardization is actually required on the ledger level. Multiple ledger types exist for a reason, as they vary one from another by features such as consensus mechanism, smart-contract coding language, resource requirements, and more. They also vary by their suitability to specific use cases.

It is technically impossible, at least at the time this document is written, for ledgers of different types to use the same chain. Thus, standardization of the ledger layer should not focus on reducing all variants of ledgers down to one common ledger type or to one common chain type, but rather on

promote interoperability between different ledgers. One possibility is to create a standard method to link or refer to records that exist on different chains created by different ledgers. A technique called atomic swap may be used where at least two parties want to exchange digital assets without intermediaries. It can theoretically be implemented on any chain but it easier between ledgers that share some features (like the same consensus algorithm).

Standardization at the application level is where the industry should probably focus. One must keep in mind that to-date, all applications are proprietary developments. While DLT may disintermediate hierarchical top-level repositories, the applications remain the IP of the developers thereby creating a vendor-lock-in. When the application is developed in-house and serves a single organization, this may not pose a problem. However, in instances where the application serves multiple (sometimes competing) entities, vendor lock-in is a situation to be avoided. Vendor lock-in creates dependency, reduces diversity and increases operational risks. This is where standardization can bring real benefit. To begin with, there are certain functions, such as identity and payment, which are common to the vast majority of use cases. Those functions would be the first candidates for standardization. Other functions may be more use-case specific and it may make sense to dissect them to what one may define as an MVP (Minimum Viable Product) and VAF (Value Added Features). Standardization of MVPs would then allow developers to compete on the VAFs, differentiating their offering from that of others. A common approach towards standardization would be to build an abstract RA (Reference Architecture) that defines the basic building blocks, and their relations/information-exchange points. Then, one would build a common IM (Information Model) and DMs (Data Models) that are derived from the IM and define the structure of the information flows between the building blocks (through the information-exchange points). The next phase would be to look at the functionality of each building block and define it using state-machines or flow-diagrams for all lifecycle operations of the entire application which then constitute the standard operation of such blocks that developers should built to. It is not uncommon that when use cases (MVPs) are being added, commonalities are discovered thus making certain developments in one MVP reusable in another.

Another important aspect of standardization is portability of applications between ledger types. Clearly, each ledger has a somewhat different northbound (ledger to application) interface that requires, as a minimum, different APIs (AKA "2nd layer"). However, with the use of different coding languages for smart-contracts by each ledger, such portability may require rewriting the contracts which, to-date, is a manual task. It would be of benefit to develop a standard abstract smart-contract template that can then be automatically compiled to the ledger of choice. Though it may look farfetched by combining application portability between ledger types and standardizing linking or referring records between chains, we allow interoperability of applications that run on any type of ledger.

Data portability is also relevant both in a context of application portability. Additionally, there are no standards for data exchange between ledgers (through inter-chain interoperability) that may include public keys, hash values, tokens or other data managed by smart contract.

There is work underway to develop platform-specific standards like fungible (e.g., ERC-20) and non-fungible tokens (e.g., ERC-721) created via Ethereum Request for Comments in the Ethereum ecosystem.

Looking at the different use cases presented to Focus Group DLT, it would be safe to state that most of them will benefit from the adoption of a standardized approach to application development. It is not recommended, at this stage, to enforce the choice of ledger type (e.g., Ethereum, HyperLedger, a proprietary ledger or any other ledger available for use) per use-case type, but it is recommended that the industry develops guidelines highlighting the benefits and disadvantages of different ledgers and thus their level of suitability for use cases of different natures. ITU-T Technical Specification FG DLT D3.1 and ITU-T Technical Specification FG DLT D3.3 can assist in platform evaluations [ref-DLT-D3.1, ref-DLT-D3.3].

From electronic mortgages to pharmaceutical supply chains and distributed energy generation to public sector loans, all applications can take advantage of cost reductions and the interoperability inherent to standardized interfaces. A core benefit considered with standard interfaces is the portability of solutions between alternative service providers.

11 Key findings and recommendations

This document contains a small sample of use cases in the distributed ledger technology (DLT) universe. The ITU-T Focus Group received dozens of use cases from all over the world. The spectrum of applications is as diverse as expected and confirms the vision that DLT is a foundational technology [ref-I-1]. The majority of use cases received are applying DLT to a specific sector of the economy, i.e., so called 'vertical' use cases. Since it is a novel technology, DLT is also used to increase efficiency and improve processes across sectors. These 'horizontal' use cases are represented in good number in the work of the Focus Group.

The Focus Group analysed and prioritized the most relevant cases. About 80% of the proposals reviewed support the attainment of one or several of the UN Sustainable Development Goals [ref-I-2]. An interesting aspect of the submitted proposals is the status of the projects. More than half are in the Proof of Concept phase which confirms that entities are still in the beginning of their DLT endeavours. There are several technical challenges, such as throughput in public networks and platform maturity in permissioned choices, as well as regulatory, governance, political, accountability, and legislative questions. A tamper-proof audit trail is among the DLT features commonly cited by use case submitters to justify the use of the technology in the respective projects. Only a few of the use cases consider utilizing crypto assets, the use of which involves several additional challenges.

DLT is not a panacea and will not be a magic-cure-for-everything. It is, however, a very effective tool that can serve to facilitate, increase efficiency and accelerate applications involving data storage and exchange that span multiple categories in our day to day life. Data is everywhere and management of data is key to the success of applications and operations. DLT offers a clear advantage to data management and exchange compared to legacy database and ledger technologies in some use cases. Its ability to combine a secure data storage mechanism, security and access management with monetary transaction capabilities makes it an efficient tool in a multitude of scenarios.

ITU-T Technical Specification FG DLT D3.1 and ITU-T Technical Specification FG DLT D3.3 have discussed reference DLT architecture standardization in length and the purpose of this clause is to review the use-case aspects of standardization [ref-DLT-D3.1], [ref-DLT-D3.3].

11.1 Recommendations to standards makers

Several types of distributed ledgers have already been created and there is a lot of additional work in progress. It is possible that some protocols or parts of protocols may be candidates for adoption as formal standards. ERC-20 is an example of a community standard for token implementation in the Ethereum network that was spread out in decentralized applications, hardware wallets and eventually was exported to other platforms such as EOS-21 teleport protocol [ref-I-3]. It is recommended that inter-chain interoperability is further studied and a standard approach to inter-chain interoperability is developed.

The existence of standards can enable cross-platform interoperability between different use cases in a way that they can seamlessly exchange their assets and information. Use cases can take advantage of standards, reuse components, utilize common interfaces and make it easier for both users and developers. For instance, a single digital identity standard can be horizontal and accommodate the needs of many use cases. It is recommended that applications and use-cases be dissected into mandatory elements (MVPs) and VAFs with the standardization efforts focusing on the MVPs.

Standards can help to clarify the scalability, decentralization, and security features of each DLT platform while enabling implementers to choose the most appropriate platform for their projects.

Considering the relatively early stage of DLT development, it is important to continuously monitor the blockchain community and other DLT implementations to identify opportunities for standardization and interoperability. Initiatives that bring together different stakeholders in the value chain such as the International Association of Trusted Blockchain Applications (INATBA)[2] and the Trusted Blockchain Initiative (China)[3], may provide valuable input for standardization work.

DLT related standardization is taking place in different standards developing organizations, I and consortia in addition to ITU-T (e.g., ISO, JTC1, ETSI, IEEE, W3C, UN/ECE, CEN/CENELEC, etc.) It is important that the different organizations liaise and cooperate to maximize resources and take advantage of synergies.

11.2 Recommendations to policy makers

Considering that the deployment of DLT implies costs and risks, there are a significant number of legal instruments to be considered, e.g., the European General Data Protection Regulation (GDPR). Laws and regulatory frameworks can have significant effects on DLT development. For example, where there is legal uncertainty, it may be prohibitive to those wanting to invest in DLT.

Policy makers should also be aware of the difficulty to find the appropriate venue to solve a legal dispute in decentralized systems. It is also a challenge to predict whether a platform is going to be used for unlawful activities. The recommendation is to monitor and verify whether additional policies are required. One strategy adopted by some countries is to create a regulatory sandbox to promote innovation with the supervision of the appropriate regulators. This recommendation would enable the testing of any new approaches suggested and allow for any adjustments to be made based on the advancements made in DLT. Furthermore, it can be the basis of creating legal frameworks to aid in defining the jurisdiction for DLT and mechanisms of determining ownership of liability.

11.3 Recommendations to industry

It is fundamental to check if a specific industry can benefit from DLT. Since most industries need ledgers to manage productivity and business relationships, it is likely that relevant use cases for DLT can be identified in most industries. One interesting point here is that a competitor can also be a node and an important partner in a DLT project. This kind of alliance is useful to promote open competition while improving business process efficiency and eliminating costs. The result could even be entirely new business models. The use cases where DLT minimizes intermediaries generally result in the greatest cost effectiveness, therefore a recurrent question is to verify whether an entrenched trusted third party (TTP) is replaceable by a DLT platform [ref-I-4] or if the TTP role is, at minimum, positively changed.

Efforts to identify these optimal use cases have resulted in numerous domestic and international consortia of companies, universities, and developers. Several countries are investing in building a national digital infrastructure based on DLT (see, for instance [ref-I-5]). Other types of networks are being pursued by multinational companies from different industries, e.g., the Libra Association [ref-I-6]. In any case, industry participants should respect the data in DLT systems of its clients, users and employees and adapt its information security policy. Before implementing DLT in a specific industry, an end user security policy should also contain ways to mitigate against any risks that those with access to the DLT systems may create.

As DLT represents a new type of software, it implies new potential vulnerabilities, security risks, and externalities.

[2] https://inatba.org/

[3] http://www.trustedblockchain.cn/

11.4 Recommendations to implementers

A wide range of DLT-based applications are now being proposed and there remains a shortage of capable implementers of these projects. Implementers should carefully evaluate projects in which DLT adds significant overall value over existing solutions such as a centralized system or an ordinary distributed database. Due to the immutable characteristics of DLT, project implementation is not conducive to the fail-fast philosophy commonly applied by Silicon Valley's start-ups. Therefore, it is recommended to invest more in the initial phases of implementation and in the establishment of an effective quality assurance (QA) process to prevent the occurrence of software bugs and future incidents, which can potentially generate huge losses, platform abandonment, forks, etc. Some people praise the Bitcoin platform's simplicity since it has been operating resiliently for more than ten years.

11.5 General recommendations

Immutability is one of the key value propositions of DLT. However, just because the data is in a distributed ledger does not mean the data is accurate. A fundamental challenge of DLT is to ensure the integrity of the data added to a ledger. This fragility applies to most use cases presented to the FG DLT. It is recommended to use a robust process to ensure trustworthiness of data input, whether directly from trusted Internet of Things (IoT) devices, or workflows requiring the validation of data input from third parties.

A further recommendation applicable to any DLT project is to develop a deep understanding of the problem to be addressed, and to evaluate whether it is an advantage to apply a distributed approach. DLTs are useful to establish trust even when stakeholders involved do not trust each other. If the business case can rely on a trusted third party, or even several trustful participants, a centralized system could be a better choice.

As highlighted above, DLT will not solve all problems, but it can be an efficient tool in a multitude of scenarios. DLTs are changing current processes and will enable a range of new applications. For these reasons, many argue that DLT and blockchain will shape the next era of prosperity in finance, business, healthcare, education, governance, and beyond, creating an Internet of Value [ref-I-7].

Appendix I:

Use cases

This Appendix provides an overview of the use cases considered by the ITU-T FG DLT while developing this document. For additional details, please refer to the respective document identified by the respective Case ID in the electronic attachment to [ref-DLT-D2.1].

I.1 Finance

I.1.1 Custodian accounting of electronic mortgage

Use case summary	
Case ID	FIN-001
Contact information	Dergachev Ivan ivan.dergachev@fintechru.org Alexander Chuburkov chuburkovalex@gmail.com
Proposing Organization	Fintech Association Moscow, Russia http://fintechru.org/
Long description	Masterchain is a P2P-network with access control. The communications between the nodes of this network are based on the modified Ethereum protocol. Masterchain provides for safe record of information in a distributed ledger. The copies of this ledger are kept at each node of the network. The white paper of the Masterchain can be found at http://fintechru.org/documents/Masterchain_whitepaper_v1.1_en.pdf.

I.1.2 Digital letter of credit

Use case summary	
Case ID	FIN-002
Contact information	Dergachev Ivan ivan.dergachev@fintechru.org Alexander Chuburkov chuburkovalex@gmail.com
Proposing Organization	Fintech Association Moscow, Russia http://fintechru.org/
Long Description	Development and implementation of a software package to opening and implementation of a digital letter of credit based on a distributed ledger platform.

I.1.3 Digital bank guarantee

Use case summary	
Case ID	FIN-003
Contact information	Dergachev Ivan ivan.dergachev@fintechru.org Alexander Chuburkov chuburkovalex@gmail.com

Proposing Organization	FinTech Association Moscow, Russia http://fintechru.org/
Long description	Development and implementation of a software package for the organization of work with Digital Bank guarantees (DBG) based on the distributed ledger platform (blockchain platform "Masterchain").

I.1.4 Blockchain for insurance

Use case summary	
Case ID	FIN-005
Contact information	Rodrigo Messias Ventura ventura@88i.io
Proposing Organization	88 Insurtech Serviços Digitais e Intermediação Ltda São Paulo, Brazil https://88i.io
Long description	88 INSURTECH is a start-up company with a disruptive business model based in blockchain that revolutionize the insurance market. The company presents a cheaper, more practical, faster and more transparent way to buy and sell insurance. The interface is simplified by the use of a digital platform (app) that gives full transparency to the consumer and operated in a 24/7 shift to guarantee a faster path to contract and acquire insurance. In exchange of a cash-back, 88i is planning to have the active support of its clients to sell insurance products. Without the standard physical costs of distribution, it is expected to reduce the insurance cost up to -30% and make insurance for free. Another important feature of the business model is the possibility to customize the product. On Demand Company has won an important blockchain competition in Brazil promoted by Google (Start-up Weekend Blockchain TechStars) UNICEF has been shortlisted 88INSURTECH as a Blockchain Start-up for Social Impact with Global Scale at the Innovation Fund. And UNGM has listed 88i as a supplier number 551162, Additionally 88i was approved by Singularity University at their Global Start-up Program GSP.

I.1.5 Unifying economies of goods & services and of information

Use case summary	
Case ID	FIN-006
Contact information	Bradley Clarke bradley@rsr.dev
Proposing Organization	Resurgence Labs, USA
Long description	A major problem of informal economies is that assets within the economy have no way to be exposed to leverage or interest-based investments. Tying physical inventories to a virtual currency opens an avenue for goods to also be leveraged. Formalizing a goods & services economy on the blockchain also allows for the pinpoint delivery of aid via community incentives. In other contexts, this would be called "gamification". Tying aid to "interest" on goods stored helps ensure that the amount of aid injected into the economy does not overwhelm organic growth of the economy, serving as scaffold for growth rather than creating a dependence on aid. We propose the formalization of the information economy on a microblogging platform, where participants in the network are able to reward each other for efforts in creation and curation of content. This economy would share the same currency as the layer for goods and services.

	By adding a social layer, good actors can visibly identify themselves as participants in both the goods & services and the information economies. Gamification can be used to coordinate incentivized behaviour. Each transaction can optionally be broadcast on the network for visibility.

I.1.6 Global ecosystem for financial inclusion and sustainable development growth

Use case summary	
Case ID	FIN-007
Contact information	Taynaah Reis taynaah@moeda.in
Proposing Organization	Moeda Semente Brasil – Desenvolvimento de Software e Serviços Financeiros S/A Brazil www.moedaseeds.com
Long description	Moeda is an ecosystem of companies (Fintech, Accelerator, Crypto Exchange, Marketplace and BLOC Impact Fund Ventures) that uses blockchain technology to revolutionize finance by connecting mission-driven investors with community-owned enterprises and providing the means for alternative financing, knowledge, resource exchange, and collective action.

I.1.7 E-money token standard

Use case summary	
Case ID	FIN-008
Contact information	Ismael Arribas standards@alastria.io
Proposing Organization	Iobuilders Kingdom of Spain https://emoneytokenstandard.org/
Long description	A proposed standard for e-money, bank and central bank money issued tokens.

I.2 Healthcare

I.2.1 Pharma: Supply chain finance in pharmaceutical industry with DLT

Use case summary	
Case ID	HLC-001
Contact information	Michael Dong dongning@chainnova.com
Proposing Organization	ChainNova Data Technology (Nantong) Co. LTD, PRC. www.chainnova.com
Long description	This use case is a proposal to trace the logistics of medicines and provide lower-cost financial support for the trader on pharmaceutical industry chain. In traditional pharmaceutical supply chain, we see the issues like fake medicines, fragmented medical logistics, untransparency of trading processes and restriction of credit grantees for SMEs. In this use case, ChainNova built a pharmaceutical supply chain financial platform based on DLT technology which can make the whole trading process traceable and increase trust among the participants on the supply chain.

I.2.2 Pharma: Blockchain web/mobile application for vaccine supply chain

Use case summary	
Case ID	HLC-002
Contact information	Dr. Agnes Naliaka Mindila amindila@icsit.jkuat.ac.ke
Proposing Organization	Jomo Kenyatta University of Agriculture and Technology Kenya
Long description	Developing countries face challenges in the vaccine supply chain. The Challenges threaten vaccine access, availability, and quality. As countries adopt newer and more expensive vaccines and attempt to reach people at different ages and in new settings, the supply chain must be optimized. Information about demand, stock-levels and timely use of vaccines is poorly kept affecting timely supply leading to expirees and/or lack of needed vaccines. There is also the risk of poor product quality and counterfeiting that countries face and avoidable wastage. Accurate data collection, secure data storage and a flow of trusted information between parties is required. Development of Permissioned Blockchain-based web/mobile application will enable incorporation of Identity Management technologies, achieve end to end visibility with the incorporation of BLE iBeacon technologies, GS 1 data matrix codes and map the physical to the digital. The application will achieve transparency and traceability within the vaccine supply chain through the use of immutable record of data and transactions, distributed storage, rules enforcement, and controlled user accesses. This will ensure every vaccine in the supply chain can be isolated, analysed and all activities associated with it identified. Data analytics and creation of dashboards for decision makers will be possible.

I.2.3 Pharma: Drugs distribution ledger

Use case summary	
Case ID	HLC-003
Contact information	Vadim Likholetov vadikas@setere.com
Proposing Organization	Limited Liability Company "Tech Medical Group", INN http://www.setere.com Russian Federation
Long description	Main conditions of success scenario: All the medical centres and pharmacies are connected to DDL Patients can get treatment reports via the internet All the necessary drugs distribution reports are being provided by DDL The implementation of DLT solution, which allows tracking medical treatments and provides the necessary reports can reduce paperwork and increase common efficiency.

I.2.4 Medicine: Blockchain for bone marrow, blood, and organ donation

Use case summary	
Case ID	HLC-005
Contact information	Cathy Chen cathy.chen@lifeblocs.com
Proposing Organization	LifeBlocs www.lifeblocs.com United States

Long description	LifeBlocs is a start-up that aims to increase blood, bone marrow, and organ donations, and optimize the matching process between donors and receivers. Powered by the Ethereum blockchain, LifeBlocs hopes to optimize supply chain efficiency by equipping each actor in the donation supply chain with a data storage and matching process, from donors and donor organizations to hospitals and patients. It hopes to give patients their much-needed access to healthcare essentials by offering a secure data storage and higher rate of match compatibility, thereby enabling timely availability of life-saving material. In executing its mission, LifeBlocs aims to save human lives by providing the following solutions: 1. An easy-to-integrate, decentralized data storage and matching platform that enables greater access for patients, and fosters collaboration between organizations and nations; 2. An incentive system that rewards blood and bone marrow donors through a non-monetary incentive, and through which donors can visualize the impact of their donation; 3. Spreading awareness and increasing the participation of donors worldwide. Finally, through the implementation of LifeBlocs' system in multiple smart cities and the learnings gathered in this process, it also plans to provide its system in countries where existing donor systems do not exist.

I.2.5 Medicine: Health data records

Use case summary	
Case ID	HLC-006
Contact information	Valeria Queiroz valfqueiroz@gmail.com
Proposing Organization	My Health Data Brazil
Long description	My health data, using the blockchain technology, invites everyone to create a health data network whose basis should be: 1. Empowerment of people, where the individual is not the patient, but the agent, the generator and the owner of their information; 2. User centralized data generation capable of providing the network with reliable and faithful information; 3. Generation and transmission of consistent information, capable of assisting in medical, pharmaceutical and wellness research and remunerating the parties involved; 4. Creation of an "anti-fragile" system, supported by multiple nodes of the network, encryption, anonymity and database not corruptible and, at the same time, generic capable of adapting to multiple situations, people and cultures easily; 5. User-focused solution, in which the Individuals will always be at the forefront of institutions, whether they are governments or for-profit entities.

I.3 Information and communication technology

I.3.1 Global marketplace for mobile operators and service providers

Use case summary	
Case ID	ICT-001
Contact information	Alexander Yakovenko ayakovenko@clementvale.com

Proposing Organization	Clementvale Baltic OU Estonia
Long description	This use case is a proposal to create global market place for mobile operators and service providers with the use of private Blockchain ecosystem. The main goal is to enable mobile operators and service providers to interact directly and securely without any agreements, intermediators and complex integration via smart contracts. This solution significantly simplifies all processes, eliminates old-fashioned roaming technology, shifts principles of interaction, reduces costs on all levels, gives an easy and quick access to global market for all players in a short period of time with almost zero investment, gives a good opportunity for mobile subscribers to use services at reasonable rates worldwide, changes principles of settlements, making them in real time in stable coin. We created one of the stable token that equals 1 SDR used in telecommunications, which is tied to the basket of five world currencies. We named it SDRt (SDR Token). It's the unit of payment given to providers for their services, i.e., the price of services is measured in these units.

I.3.2 Automatic discovery, quote, ordering and settlement in a mesh of interconnected ICT service providers

Use case summary	
Case ID	ICT-002
Contact information	Shahar Steiff ssteiff@pccwglobal.com
Proposing Organization	PCCW Global Limited Hong Kong, China www.pccwglobal.com
Long description	Describe PoC conducted at MEF18 event that demonstrated Automatic Discovery, Quote, Ordering and Settlement in a Mesh of Interconnected ICT Service Providers resulting in a significant decrease in time compared to legacy manual processes.

I.3.3 Wholesale voice settlement

Use case summary	
Case ID	ICT-003
Contact information	Shahar Steiff ssteiff@pccwglobal.com Gal Hochberg gal@clearx.io
Proposing Organization	PCCW Global LTD, Hong Kong, China Clear, Singapore
Long description	Billing and settlement for voice calls involving multiple carriers requires processes that span multiple business entities, and current practices are unlikely to remain viable for at least two reasons: 1. Settlement generally relies on third party clearing houses, to whom carriers must disclose sensitive commercial data and who charge a fee. With margins shrinking, those fees are becoming a significant drag on the profitability of voice services. 2. While the basic data transfer is largely automated, the process of dispute resolution is still largely manual. Moreover, disputes themselves are extremely common, and the resolution processes are long. Litigation in these disputes is not uncommon. These factors combine to make the process expensive. A DLT solution addresses these issues: first, a bilateral relationship can be managed between the parties directly, without the need of a neutral referee. Secondly, smart

	contracts process data securely between the parties and resolve most disputes automatically, based on rules negotiated and agreed in advance on resolving the most common types of discrepancies. Finally, a DLT solution can integrate the entire settlement pipeline, with the actual payment being handled by electronic means (e.g., SWIFT transfers of fiat currencies or through via cryptocurrencies, possibly ones created for the purpose of intercarrier settlement).

I.3.4 Distributed ledger based online trading system for cross-domain VPN provision

Use case summary	
Case ID	ICT-004
Contact information	Xinpeng Wei wexinpeng@huawei.com Bingyang Liu liubingyang@huawei.com
Proposing Organization	Huawei China
Long description	A virtual private network (VPN) extends a private network across a public network, and enables users to send and receive data across shared or public networks as if their computing devices were directly connected to the private network. Usually the VPN connection will cross one or more networks operated by different operators, and the operators should have SLAs between each other to setup of end-to-end VPN connection for customers, the process of setup VPN could take a very long time both due to technology issues and SLA issues between operators, but because the VPNs are usually static provisioned and once setup it will maintained for a very long time, so the time taken for VPN setup is acceptable. However, as the new cases that VPN should be setup in a more flexible and on-demand way, the existing solution for VPN setup is no longer acceptable, because it is usually unknown which operator's network to traverse and whether the en route operators has SLAs between each other. This document provides a use case that DLT is used for on-demand VPN connection setup across different domains.

I.3.5 Distributed ledger based online trading system for DdoS mitigation services

Use case summary	
Case ID	ICT-005
Contact information	Xinpeng Wei wexinpeng@huawei.com Bingyang Liu liubingyang@huawei.com
Proposing Organization	Huawei China
Long description	This use case describes how DLT is used in DdoS mitigation service. Distributed Denial of Service (DdoS) attacks combine multiple distributed attack sources to attack a single victim, thereby amplify the attack power and downgrade the services of the victim network. DdoS mitigation service aims at mitigating DdoS attacks for the victim network. By using DLT, it's much easier to mitigate attack at the point of attack sources, and prevents the attack traffic from consuming bandwidth resources of the intermediate networks.

I.3.6 DLT for number assignment, services and number portability

Use case summary	
Case ID	ICT-006
Contact information	Philippe Fouquart philippe.fouquart@orange.com Alex Nikolov alex.nikolov@commssolutions.com
Proposing Organization	Orange, France VISIONng, UK
Long description	Solution for global number and service portability that provides fast cost effective and scalable technology for global services deployment.

I.4 Arts, culture and entertainment

I.4.1 Arts: Engaging stakeholders in blockchain and satellite futures

Use case summary	
Case ID	ENT-001
Contact information	Denisa Reshef Kera denisa.kera@usal.es
Proposing Organization	BISITE, University of Salamanca, Spain
Long description	Lithopia is a parody of a "smart" blockchain-managed village that uses open satellite data to trigger smart contracts on the Hyperledger Composer/Fabric (https://github.com/anonette/lithopia). It reflects the current search for national cryptocurrencies and speculative investments in mining, such as ICOs or Lithium reserves in the Czech Republic. It is a functional prototype of a Node-RED interface/dashboard connected to the blockchain smart contracts on Hyperledger over a REST API service. It uses open data from Sentinel 2A Copernicus to change ownership of a location or a resource when covered by 10 x 10 m textile creating a pixel of data for the satellite. The project supports inclusive and democratic "future-making" (anticipatory governance) against the current misuses of emerging technologies in the so-called predictive, anticipatory and frictionless design. The villagers in Lithopia govern their affairs in an extremely transparent, but also aesthetic manner. Special long gestures and large LiCoins, but also acts of covering spaces in a land-art, Christo manner trigger the transactions. Lithopian DLT is inspired by Micronesian island of Yap that uses large stone coins to preserve their oral memory of ownership, marriages, and important events. Lithopians deploy smart contracts as a form of oral culture timestamping emphasizing genealogy over exchange and stewardship over ownership. The project was currently installed at the Milan design Triennial until September 2019.

I.5 Industries

I.5.1 Energy: Energy distribution with the use of smart contracts

Use case summary	
Case ID	IND-001
Contact information	Ioannis Kounelis, ioannis.kounelis@ec.europa.eu Gary Steri, gary.steri@ec.europa.eu
Proposing Organization	European Commission https://ec.europa.eu/jrc/en

Use case summary	
Long description	In our model, we assume a local grid where energy is produced and consumed in a limited geographical area, such as a local neighbourhood. Energy produced by a prosumer may be saved in the user's local battery for later use or may be immediately injected in the local grid. An additional possibility is to have a common, central to the neighbourhood, battery shared as a temporary energy buffer. The model is divided in three layers: (a) the energy grid, (b) the middleware controller, and (c) the smart contract. When energy is injected in the grid a smart meter linked to each producer continuously measures how much energy has been injected in total. These smart meters, along with the software that handles their output, i.e., a middleware controller, are the input source for our smart contracts. After a predefined amount of energy has been injected to the grid, a Helios Coin (HEC) is awarded to the corresponding prosumer. The middleware controller interconnects the grid with the smart contract since these systems cannot communicate directly with each other. As a result, the controller plays the role of invoking the smart contract on one end, and on the other receiving the readings from the grid, thus facilitating communication between the two entities.

I.5.2 Energy: P2P energy trading

Use case summary	
Case ID	IND-002
Contact information	Igor Ferreira igor.ferreira@fohat.co
Proposing Organization	FOHAT Corporation Brazil https://fohat.io/
Long description	By tokenizing the Energy Trading platform (RAPTOR) we will allow Prosumers to trade the energy from their Distributed Energy Resources (DERs) like solar panels, batteries and electrical vehicles in a peer-to-peer transactive network (P2P TE). That will allow people to Bring Your Own Devices (BYOD) into the Microgrids, which promote grid expansion and improves reliability and resilience of the grid network.

I.5.3 Climate industry: Reverse logistics credits

Use case summary	
Case ID	IND-003
Contact information	Lucas Farias de Moraes Sarmento lucas.sarmento@brpolen.com.br
Proposing Organization	Polen Consultoria e Intermediaçáo de Negócios em Sustentabilidade LTDA Brazil
Long description	Post-consumption waste Reverse logistics compensation scheme using DLT as infrastructure to issue Reverse Logistics Credits, which can be used by companies wishing to offset and incentivise the recycling of the waste generated by the consumption of the products they sell to the public.

I.5.4 Climate industry: Carbon removal marketplace

Use case summary	
Case ID	IND-004
Contact information	Ross Kenyon ross@nori.com

Proposing Organization	Nori LLC, Washington, United States https://nori.com/
Long description	Nori is a carbon removal marketplace. We focus exclusively on helping carbon removal practitioners get paid for removing CO2 from the atmosphere. Existing carbon markets primarily focus on avoided emissions. We have learned a lot from their experience but have made a number of design choices that we believe improves credibility, efficiency, and deservedly treats carbon removal as a discrete activity. Our technology and carbon removal methodologies are open source, and we have opened our first pilot project for farmers engaging in regenerative agriculture. As a result of carbon removal's mechanics and the transparency of blockchain accounting, we can far more credibly guarantee that a tonne of carbon dioxide removed and represented by a Carbon Removal Certificate is actually removed. Our NORI token trades at a ratio of 1:1 against the CRC, which will create a market-driven price on carbon for the first time in history, something akin to the Brent Crude or West Texas Intermediate prices used for forecasting in petroleum. A simple and scalable system that allows even small carbon removers to monetize their activity could see the emergence of a trillion-dollar carbon removal industry.

I.5.5 Supply chain management: Pig farm monitoring & data traceability

Use case summary	
Case ID	IND-005
Contact information	Hui Ding hui.ding@chaincomp.net
Proposing Organization	Chaincomp Technologies Co., Ltd. China Shenqiao Technologies Co., Ltd. China
Long description	Currently, small to medium size pig farms (around 500 pigs per farm), which provide over 50% of total pigs (693.82 million in 2018) in China, cannot provide trusted data collection and traceability and gives chances to food safety hazards that happened in recent years. Our use case provides Blockchain-based IoT solution to pig farms and realizes: 1) IoT-based effective and complete pig farm monitoring and data collection; 2) Blockchain-based data storage and dissemination. The system can automatically record the environmental, physiological and feeding data and enables efficient and trusted data storage and sharing among stakeholders. After deployment of such system, a number of benefits can be achieved, such as 1) government inspector can access tamper-proof data to evaluate the farms and the quality of the meat; 2) consumers will be able to access the details of his/her purchase and be assured of food safety and quality; 3) furthermore, it enables lower cost of business operation: farms, feed/drug sellers, insurance providers can share information via DLT to perform transactions in lower cost.

I.5.6 Supply chain management: Responsible gold ecosystem

Use case summary	
Case ID	IND-006
Contact information	Victor Vilmont victor.vilmont@emergenttech.com Stephen Grinalds stephen.grinalds@emergenttech.com Kevin Cussen kevin.cussen@emergenttech.com

Proposing Organization	Emergent Technology Holdings (EmTech) United States
Long description	Gold due to its intrinsic nature is susceptible to money laundering, conflict sourcing, and financing of terrorist activities. There is increasing pressure on supply chain participants to demonstrate that their production practices do not contribute to conflict or any environmental, health and safety concerns. EmTech's Responsible Gold Ecosystem ("Ecosystem") provides a much-needed solution to the increasing transparency and trust burden. The Ecosystem helps enhance integrity in the global gold supply chain by using DLT to irrefutably and immutably record ethical provenance and chain of custody from mine, to refinery, to vault or fabricator. It is underpinned by EmTech's Responsible Gold Standards, a set of critical environmental, social and governance (ESG) risks and controls for the precious metals industry. The Standards provide a framework by which participants can attest that their gold production practices adhere to the highest industry requirements, manage their impacts on workers, communities and the natural environment, and generate positive ESG impacts. EmTech is committed to sustainable development by: – Supporting participants in embedding responsible business practices; – Connecting responsible companies and people in one Ecosystem; and – Trading Responsible Gold

I.5.7 Supply chain management: Traceability in the food supply chain in Brazil

Use case summary	
Case ID	IND-007
Contact information	Rodrigo Lima Verde Leal rodleal@cpqd.com.br
Proposing Organization	Fundação CPqD – Centro de Pesquisa e Desenvolvimento em Telecomunicações Brazil https://www.cpqd.com.br
Long description	This Pilot is the first step for providing provenance and quality information to all relevant stakeholders in the food supply chain. The DLT-based system creates a digital identity for each asset being traced, which contains information that is needed for an end-to-end audit trail perpassing all stakeholders in the supply chain, from producers to retailers, that is both safe and reliable. For instance, if a disease in a given farm or region is detected, all by-products from those animals that may be contaminated can be traced back more efficiently and with lower costs due to recalls. The integration of DLT to Safe Trace's system provides transparency, reliability and immutability of data to all relevant stakeholder in the beef supply chain. Other characteristics that are also important to consumers, such as social and environmental compliance of farms, animal wellbeing and quality assessments throughout the supply chain, can also be part of the solution. In this Pilot, CPqD created the DLT-based network and smart contracts (aka chaincodes), as well as the services layer, which includes the integration APIs for legacy systems, which are also part of the network. The development framework is Hyperledger Fabric, maintained by The Linux Foundation.

I.5.8 Supply chain management: Trade facilitation and customs management

Use case summary	
Case ID	IND-008
Contact information	Lewis Freiberg lewis@iota.org
Proposing Organization	IOTA Foundation Germany https://iota.org
Long description	Cross-border trading involves a selected number of actors, including but not limited to: shippers, forwarders, customs and traders. Such actors are involved in a number of processes dealing with the following challenges: – How trade certificates can be shared and checked for authenticity even before a shipment is initiated or when it is already on its way; – How the different actors handling a shipment can report its status (e.g., cleared for export, Gate-in into the port, on-board a vessel etc.); – How the different actors can share an auditable record of the conditions of the shipped goods (temperature, location, shock, etc). Due to the multi-stakeholder nature of these processes, simplifying them requires the creation of a data exchange layer which uses the IOTA Tangle and other IOTA technologies. IOTA DLT helps to ensure the integrity of data and to maintain trust among the parties involved in the international shipment of containers goods.

I.5.9 Supply chain management: Multimodal logistic corridor

Use case summary	
Case ID	IND-009
Contact information	Ingrid Barth ingrid@cosmosblockchain.co
Proposing Organization	Polo Multimodal Pecem Fortaleza, Brazil http://www.polomultimodal.com/
Long description	Polo Multimodal Pecem is a project with over 20 million square meters located in the logistic corridor of Port of Pecém, in the municipality of São Gonçalo do Amarante, State of Ceará. Conceived to house both national and international companies from different sectors, the POLO MULTIMODAL PECEM was designed within the most modern and rigorous criteria of infrastructure, technology and sustainability; promoting innovation to contribute to the progress of a new industrial age. The idea is also having a Blockchain Lab inside de Polo, with the intention to create blockchain and DLT solutions for all opportunities there. The first idea, based on problems that companies are having in all Ports around the world, is create a solution in a public Blockchain to help companies register in blockchain, in a permanent way and using the time stamp, all tracking about goods, process, containers, flows, in order to bring more security, avoid losses and create new solutions for the flow. Also, other benefits as hold all data and use it for further works – provide data for insurance companies to have a best score and price.

I.6 Government and public sector

I.6.1 Public sector lending transparency

Use case summary	
Case ID	GOV-001
Contact information	Suzana Mesquita de Borba Maranhão Moreno suzana@bndes.gov.br
Proposing Organization	BNDES Rio de Janeiro, Brazil https://www.bndes.gov.br/
Long description	This use case is a proposal for changing the process of lending projects in The Brazilian Development Bank using a stable coin with DLT technology. The stable coin is used when disbursing money from BNDES to the client and from the client to contractors. Then, the contractor can redeem to get its fiat money. It is a closed ecosystem between BNDES, clients and contractors in order to avoid regulatory risks. In order to achieve the desired transparency, it is necessary to identify everyone who do transactions using the stablecoin. In future view, there is also important to identify services and products offered from contractors to clients. The main goal is to achieve more transparency of the public money allocation. However, the new proposal achieves other benefits like operational costs reduction and the generation of data to support aggregate analysis of the benefits arising from the bank's loans.

I.6.2 Accountability and transparency in fundraising

Use case summary	
Case ID	GOV-002
Contact information	José Nogueira D'Almeida Jr. nogueiradalmeida@gmail.com
Proposing Organization	BNDES Rio de Janeiro, Brazil https://www.bndes.gov.br/
Long description	The Amazon Fund is a REDD+ mechanism created to raise donations for non-reimbursable investments in efforts to prevent, monitor and combat deforestation, as well as to promote the preservation and sustainable use in the Brazilian Amazon. The Amazon Fund is managed by BNDES, the Brazilian Development Bank, which is responsible for raising and investing funds, monitoring the projects supported, rendering accounts and communicating results obtained. Germany is one of the main donors of Amazon Fund. The Germany's Development Bank KfW and BNDES are cooperating to use the blockchain technology to record how funding is spent. The Trubudget is a generic blockchain system that allows to register workflows. The Trubudget for the Amazon Fund is a use case that registers the money flow. It started in 2017, it had a Proof-of-Concept Phase in 2018 which consisted in simulations with real clients and in 2019 is in the Pilot Phase, which consists in real disbursement monitored and controlled by the blockchain. The payments process from BNDES to its Clients was the choice to be recorded on Trubudget blockchain in the Pilot Phase

I.6.3 Law-making

Use case summary	
Case ID	GOV-003
Contact information	Marco Konopacki marco@itsrio.org
Proposing Organization	Institute for Technology and Society Brazil
Long description	Mudamos is a mobile application that enables Brazil's citizens to participate in lawmaking by proposing their own bills and signing onto one another's proposals using verified electronic signatures. Any citizen with a smartphone (Android or iOS) can download the app and register with his or her electoral ID, name and address, information which Mudamos keeps secure and verifies with Brazil's Electoral Court. The app issues what is known as a cryptographic key pair, a small piece of code used for verification. One half of the key is stored on the user's phone and the other with Mudamos, which makes it possible to authenticate a person's signature. In this way, members of the public can draft and sign petitions in a way that is verifiable and secure.

I.6.4 Real time tax compliance

Use case summary	
Case ID	GOV-004
Contact information	Priyanka Desai priyanka.desai@consensys.net Anne T Griffin anne.griffin@consensys.net Kirsten Albers-Fiedler kirsten.albersfiedler@consensys.net
Proposing Organization	OpenLaw (ConsenSys) United States
Long description	The premier open source protocol to rapidly build commercial relationships on blockchain technology. OpenLaw makes it easy to automate agreements, collect secure e-signatures storing them on the blockchain, turn legal agreements into simple forms, tokenize assets, and execute, trigger, and halt smart contracts. Additionally, OpenLaw has free open source legal agreement library, that gives people around the world easier access to justice and the law for resources that can cost thousands of dollars elsewhere. This technology supports individuals, corporations, and governments in building powerful but simple solutions to complex problems. OpenLaw supports, but is not limited to, use cases such as automatic tax collection and alternative dispute resolution that help communities by making sure public services can be paid for and access to justice.

I.6.5 Improving governance authenticating identities, authorization signatures and digital content

Use case summary	
Case ID	GOV-005
Contact information	Edilson Osorio Junior osoriojr@originalmy.com
Proposing Organization	OriginalMy Blockchain OÜ Estonia

Long description	Founded in 2015, OriginalMy envisions a world in which individuals and entities have a balanced alignment of interests and are empowered to take necessary actions that build Trust in the e-Governance for the benefit of the entire organization. The challenge to achieve that vision is building Trust and increase the overall governance process while providing compliance, risk management and cybersecurity tools that cannot be flawed, corruptible, temperable and non-verifiable – because of centralization. The solution is presenting a trusted and immutable blockchain framework with: – The next generation of Digital Identity & storage of assets; – Seamlessly authentication with proof-of-authorship; – Single Sign-On, with control of delivering of personal data; – Authentic signed documents, contracts and transactions; – Proof-of-authenticity for digital content; – Blockchain-enabled e-voting systems; This approach is trustful because it improves the overall e-Governance reducing costs and saving time, is flexible to address an array of risk and compliance needs, performs traceability of all digital acts performed and has the security provided by blockchain cryptography protocols.

I.6.6 Diploma verification

Use case summary	
Case ID	GOV-006
Contact information	Pierre-Yves Burgi Pierre-Yves.Burgi@unige.ch
Proposing Organization	University of Geneva Switzerland
Long description	The falsification of university certificates is a major problem. Since diplomas are often only presented as scans, forging them has become very easy. As a result, the University of Geneva is being confronted with an increasing number of verification requests. A pilot application has been developed that uses a legally regulated seal and a timestamp on a public blockchain (Ethereum) to prove the authenticity of a diploma. The document is verified by using the original PDF/A-file or a short summary of the diploma. The use of a public blockchain ensures that the diploma can be proven even in the case of the university not being able to confirm its validity anymore.

I.7 Identity management

I.7.1 National identity network

Use case summary	
Case ID	IDM-001
Contact information	Ismael Arribas
Proposing Organization	"Consorcio Red Alastria" Association Kingdom of Spain https://alastria.io/
Long description	Thanks to the diversity of its stakeholders and associates, Alastria has granted an infrastructure for Self-Sovereign Identity management. As a network it is dully authenticated in the Spanish market and European Union, however the partnership with LAC countries which is a fact of the SDG 17 scope for Alastria is the consequence for being a framework of networks. Alastria is the first multisectoral Association promoted by organizations and institutions for the establishment of a public Blockchain/DLT

	infrastructure, supporting services with legal effectiveness in the Spanish scope and according with the European regulation. The Consortium is open to any organization that wishes to have available a fundamental tool for the development of its own blockchain/DLT strategy with the aim of distributing and organizing products and services

I.7.2 Digital identity as a service

Use case summary	
Case ID	IDM-002
Contact information	Alexander Yakovenko ayakovenko@clementvale.com
Proposing Organization	Clementvale Baltic OU, Estonia
Long description	This use case is a proposal to implement Digital identity with the use of DLT and use it as a service.

I.7.3 Using human factors and a social graph to bootstrap ID

Use case summary	
Case ID	IDM-004
Contact information	Christopher Hughes Christopher.hughes@gmail.com
Proposing Organization	JPMorgan Quorum Developers New York, USA
Long description	Self-sovereign ID using a social bootstrapping mechanism (using a plurality of attestations) allow humans to self-initialize identification. This aids in identification of displaced people/refugees. Once ID layer is initialized; allow additional attestations for education, professional certifications, or other relevant social data points.

I.8 Security management

I.8.1 DLT based decentralized public key infrastructure system

Use case summary	
Case ID	SEM-002
Contact information	Xinpeng Wei wexinpeng@huawei.com Bingyang Liu liubingyang@huawei.com
Proposing Organization	Huawei, China
Long description	A public key infrastructure (PKI) is a set of roles, policies, and procedures needed to create, manage, distribute, use, store & revoke digital certificates and manage public-key encryption. The purpose of a PKI is to facilitate the secure electronic transfer of information for a range of network activities such as e-commerce, internet banking and confidential I. Currently the PKI system is built in a hierarchical mode, one root CA exist at the top of the system and several intermediate Cas at lower level. The security of the whole system based on the security of root CA, if root CA is corrupted or misbehaviour then the whole system fails.

	By using DLT, a decentralized PKI system can be built without highly centralized root CA, and avoid the single point of failure problem.

I.9 Data management

I.9.1 Smart contracts for data accountability and provenance tracking

Use case summary	
Case ID	DTM-001
Contact information	Ricardo Neisse, ricardo.neisse@ec.europa.eu Gary Steri, gary.steri@ec.europa.eu
Proposing Organization	European Commission Joint Research Centre Ispra, Italy
Long description	The recent approval of the General Data Protection Regulation (GDPR) imposes new data protection requirements on data controllers and processors with respect to the processing of European Union (EU) residents' data. These requirements consist of a single set of rules that have binding legal status and should be enforced in all EU member states. In light of these requirements, this use case propose the use of a blockchain-based approach to support data accountability and provenance tracking. This approach relies on the use of publicly auditable smart contracts deployed in a blockchain that increase the transparency with respect to the access and usage of data. Smart contracts can be used to encode data usage policies and provenance tracking information in a privacy-friendly way.

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