# The Internet of Value

A collection of articles from the UCL CBT Research and Industry Associate Community on how Blockchain and DLT are enabling the new Internet of Value

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# Acknowledgements

We would like to thank Nikhil Vadgama for leading the creation, management and editing of this collection of articles. Jiahua Xu's contributions in editing and checking chapters was invaluable.

Many of the UCL CBT's community provided feedback and support for the creation of specific chapters where they are named. This includes Marcus Treacher, Alexandra Sims, Stylianos Kampakis, Mike Brookbanks, Philippe Rixhon, Navroop Sahdev and Danielle Mendes Thame Denny.

Thank you to Andrea Maria Consentino, Patrick Timmis and Anna Gorbatcheva for their help in editing this collection of articles and finally thanks to Cykube Ltd for the creation of the illustrations.

## Forward

*David Schwartz*

Over the past 80 years, global commerce has become a reality. First, in the form of revolutionary improvements in the physical movement of goods and then in the form of a revolution in the movement of information. But there is still a piece missing. Global payments have not been revolutionized.

Before the invention of the standard shipping container, moving goods over every form of transportation required different methods of packing. Moving from rail to ship or ship to air required delivery-specific logistics. This made the delivery of goods across continents inefficient and often impractical.

Today, shipping logistics is a solved problem. Hubs move goods easily between modes of transportation without repacking. The global shipping infrastructure works so well that we seldom have to think about it.

Similarly, TCP/IP, a “shipping container” for data, enabled information to move across different methods of conveyance as well quickly. The Internet seamlessly integrates Ethernet, WiFi, fibre optic networks, and many other technologies that did not even exist when TCP/IP was developed.

Devices can be connected to the global Internet without difficulty. It is then possible for every device to talk to every other device. A person at work can easily be notified that someone is at their door at home. We can easily discover goods and services offered for sale around the world.

While global shipping and global communication are necessary to have efficient global commerce, they are not sufficient. Truly ubiquitous global commerce requires efficient global payments. We still lack a shipping container for value. We don’t have a TCP/IP for money.

In the past, businesses found ways to avoid the need for large scale, low-value cross-border payments. A typical business only needed to pay their suppliers and only needed to be paid by wholesalers. Payments from retail customers used exclusively local payment rails.

Today’s payment systems were built for yesterday’s companies. Companies like Amazon, Airbnb, and Uber need to make fast outbound payments to customers and small businesses around the world.

Companies like these that need to make payments around the world need to integrate with numerous different payment systems. This means they need to have extensive payment operations departments, often with hundreds of employees. This means small companies cannot adopt these business models because supporting their payment needs requires a scale they do not have.

At the same time, a new borderless digital financial system is developing. Starting with the announcement of Bitcoin in 2009, blockchain technology has made possible trust-minimized systems without central operators. These systems permit the storage and exchange of value. Building on this core technology, innovation continues to add trust-minimized facilities to handle everything from loans to securities settlement.

This missing piece is a connection between these two worlds. Today, most value moves through systems that are not blockchains and cannot easily be connected to blockchains. Meanwhile, the various blockchains that have been constructed generally do not even interoperate with each other.

A way to make conventional payment systems and blockchains work seamlessly is the missing piece. Value needs to move as easily as emails move because email is everything that payments and blockchains still aren't.

Email has a global namespace. Every payment system, and every blockchain, has its way of identifying sources and destinations. If you have someone's email address, you can email them. To pay someone, you need first to find a payment system or blockchain you both can access.

Email is easy for automated systems to interact with -- a universal standard allows software to send and receive emails easily. If you set up an email server, you can exchange email with anyone willing to exchange email with you. Emails can just as easily be sent between humans, between humans and machines, and between machines. Payment systems have dozens of different methods of integration. Blockchains have their own varied and different methods of integration.

Today, we are still missing the piece that makes money move as easily as information moves. The experience of sending an international payment is nothing like the experience of sending an international email. We do not yet have an "Internet of Value". But we know we need it.

# Executive Summary

*Paolo Tasca*

**The Internet of Value**

Five decades ago, the birth of the Internet changed the way information is produced and shared. Before that, people had been resorting to disconnected channels, such as direct person-to-person communication or postal, telegraph and telephone (PTT) services, to transmit information. Through its communication protocol, the Internet can allow information to be easily and immediately accessible across the globe, irrespective of the physical locations and native languages of the users. Today, the Internet has become the pathway for people to create, store, retrieve, curate and exchange any sort of data.

Despite the advancement in the exchange and transmission of information, the exchange and transmission of "money" – or in a broader sense, "value" – continue to be siloed. Our long-standing, traditional banking system fundamentally controls monetary activities. While payment gateways such as Paypal and Stripe allow people to conduct certain types of monetary transactions inexpensively on the Internet, it remains a challenge to conduct all types of transactions people and firms need. In particular, these impairments apply to those transactions involving substantial amounts and underprivileged users from unbanked regions.

Eleven years ago, blockchain technology emerged to change the fragmented nature of our monetary system. The technology gives control over value flows to value holders, by eliminating conventionally trusted intermediaries such as banks and escrows, and by allowing all participants of the value network to contribute to the operations of the network. Peer-to-peer transactions surpassing regional and economic infrastructure restrictions become possible.

More recently, the advent of smart contracts leads to further efficiency enhancement of the value network on blockchain. A smart contract ensures that value transactions automatically occur following pre-programmed rules without human intervention. In tandem with the Internet of Things (IoT) technology, smart contracts enable machine-to-machine value transactions on blockchains. As such, within the blockchain ecosystem value can be created, stored, retrieved, curated and exchanged swiftly and cheaply just like information, forming the Internet of Value (IoV).

**The motivation for this report**

Late 2017 witnessed tulipmania-like craze about blockchain due to the skyrocketing price of cryptocurrencies and high expected return of Initial Coin Offerings (ICO). However, the enthusiasm quickly waned when investors realised the pervading scams and frauds associated with ICOs. The overall price level of cryptocurrencies plummeted afterwards, and the reputation of the companies in the blockchain sector suffered. The mantra "we have a new technology, now we need to find the problem" was not fulfilled.

Unfortunately, conventional wisdom still equates blockchain with cryptocurrency. It fails to see a wide range of uses of the technology beyond this. To date, cryptocurrency trading is mostly speculative, resulting in high price volatility and scepticism about the underlying technology.

Under these circumstances, the University College London Centre for Blockchain Technologies (UCL CBT) put together tens of its Industry and Academic experts to work together for six months to provide a variety of perspectives on:

- The massive potential of the technology that can drive the establishment of the IoV;
- Blockchain's component pieces that enable the IoV, including smart contracts, cryptography and various consensus mechanisms;
- Specific protocols that propel the development of the IoV such as XRP and IOTA.

**Key takeaways**

The most important key takeaways from this report are summarised below (see the corresponding sections for the original research articles).

- **The IoV can be defined as the instant transfer of assets expressible in monetary terms over the Internet between peers without the need for intermediaries.** The IoV can grow in the new distributed ledgers paradigm, where digital assets, namely digital representations of claims on material or immaterial assets from the physical world, remain unique. At the same time, their ownership and usage licenses are being exchanged, sent, copied, and updated without a trusted central authority. [Chapter 2]
- **The mission of the IoV is to exchange any amount of value as quickly and fluidly as information is exchanged today.** Value creation, measurement and exchange will remain the core of human society and harnessing the IoV will be its most critical success factor. [Chapter 4]
- **The IoV forms a Value Web of relationships that remove the silos of existing data structures and networks.** The IoV reduces barriers to entry, introducing a borderless economy. [Chapter 4]
- **The IoV is fundamentally enabled by blockchain.** Ensuring trust and transparency, blockchain allows new e-commerce business models to achieve quick transfers of value, whether monetary, social or perceived customer value. Across retail and consumer goods industries, collectively known as consumer markets, the areas subject to potential disruption include Loyalty, Direct to Consumer, Servitisation, Sustainability, and the areas of Data and Self-sovereign Identity. [Chapter 5]
- **Merging the IoT with blockchain technology enables more efficient machine to machine transactions, further enhancing the IoV.** As such, data can be logged in a verifiable, encrypted and tamper-proof fashion, and can be processed by self-executing machines. The network of interconnected devices will be able to interact with their environment and make decisions without any human intervention by the deployment of smart contracts. [Chapter 1]
- **Advancements in Artificial Intelligence and 5G drive the evolvement of the IoT.** The emergence of 5G will ensure low network latency, one of the critical requirements of most of the use cases with IoT. The development of Artificial intelligence will play a key role in automating complex decision-making processes. [Chapter 6]
- **The removal of intermediaries in combination with increased information transparency leads to a mitigation of the so-called principal-agent problem** where agents possess all relevant information and act in their own best interests rather than in those of the principals. The IoV helps to reduce this specific problem by applying smart contracts as well as by giving principals advanced options to monitor transactions. [Chapter 2]

- **New IoV businesses can take the form of Decentralised Autonomous Organisations (DAOs) through an optimised governance structure that incorporates decisions made by both computers and humans.** The technological innovation inevitably unlocks new ways of doing business in finance that result in the realisation of one big aim: cost saving. By leveraging these new technologies, most of the legacy cost, including labour overhead and cost incurred due to human errors that financial institutions bear in their balance sheets, can be cut down to the bone. [Chapter 3]

- **Everything that can be tokenised will eventually be tokenised – that is the foundation of the IoV**. Tokenisation increases an asset's moneyness, i.e. the degree to which an asset approximates cash and can thus be used as a medium of exchange. An asset in its tokenised form can be exchanged with little impact on its value and at low cost. [Chapter 4]

- **Through reliance on purely virtual tokens, distributed ledger technology sidesteps the complications of bridging the real/virtual divide**: a purely virtual system can address "truth" through self-containing consistency. Once the distributed ledger achieves consensus about who is entitled to control a tokenised asset, this is sufficient to effectively establish ownership in the practical sense. [Chapter 3]

- **Global central banks could cooperate to reap the benefits of recent technological advances.** Early examples of synthetic central bank digital currency (sCBDC) will drive more central banks to reactively follow suit and launch their versions in partnership either with each other or with private actors, albeit the current low the appetite for global economic cooperation. To cater to the new trend and remain competitive, centralised digital currency issuers will likely provide new on-ramping options and exchange pairs with decentralised cryptocurrencies, leading to their true mass adoption. The proliferation of new forms of money may act as a bridge and educational tool for the mainstream public to transition from legacy systems into a new tokenised economy. [Chapter 3]

- **In a distributed network, a trade-off between efficiency and robustness to attacks must be made.** The increased efficiency through the establishment of special nodes serving as hubs comes at the expenses of a high fragility to targeted attacks: If a few hubs are identified by attackers or shut down, the system breaks and will fail to perform its function. [Chapter 7]

- **While the transparent and open transmission of data on blockchain imposes privacy concerns, new protocols are being developed to protect personal and confidential information effectively.** Through zero-knowledge cryptography, transaction data can be obfuscated, and varying degrees of access to information can be implemented. [Chapter 8]

# Chapter 1: How DLT will evolve in the Future

*Theodosis Mourouzis, Nikolas Markou and Nicola Dimitri*

DLTs have changed in many ways since their inception in 2008. Few could have predicted the heights that Bitcoin has reached since then. Followed by evolutions in the form of Ethereum, Hyperledger and Corda to name but a few, what can we expect from this technology in coming years?

This section of the Internet of Value report focuses on how DLT may evolve in the future. Part A examines how DLT could transform payments and the benefits that could ensue. This is then followed by how DLT can facilitate Machine to Machine interactions and the transformative impacts of that. This part is written by Theodosis Mourouzis and Nikolas Markou.

Part B examines the future of DLT from the perspective of the evolution of consensus mechanisms. This part discusses which new consensus mechanisms could replace Proof of Work. These include Directed Acyclic Graphs, Proof of Stake and Proof of Burn. For those more mathematically inclined, this part also consists of an exploration of the dynamics of consensus mechanisms from a mathematical perspective. The second part is written by Nicola Dimitri.

This chapter was reviewed by Marcus Treacher.

# Part A: Blockchains, DLTs and the Future of Payments

*Theodosis Mourouzis and Nikolas Markou*

## DLT & payments transformation

Much of the hype around blockchains has focused on its potential to change the financial services industry fundamentally. Blockchain has promised to reduce the cost and complexity of financial transactions, making the world's unbanked a viable new market, and improving transparency and regulation.

Blockchain technology enables specific features such as:

- Bi-directional messaging with settlement instructions in payment networks;
- Improved speed in payments, settlement in almost real-time and 100% digital;
- Transparency, end-to-end tracking of payments;
- Total cost and message details confirmed before initiation;
- Lower cost for cross-border transactions;
- Reduction of failed payments and costly interventions for error resolution;
- Full tracking of historical transactional data and lower probabilities of errors;

Figure 1 shows how cross border payments operate today. One can see a variety of issues that come to light based on the utilisation of a large number of siloed intermediaries.

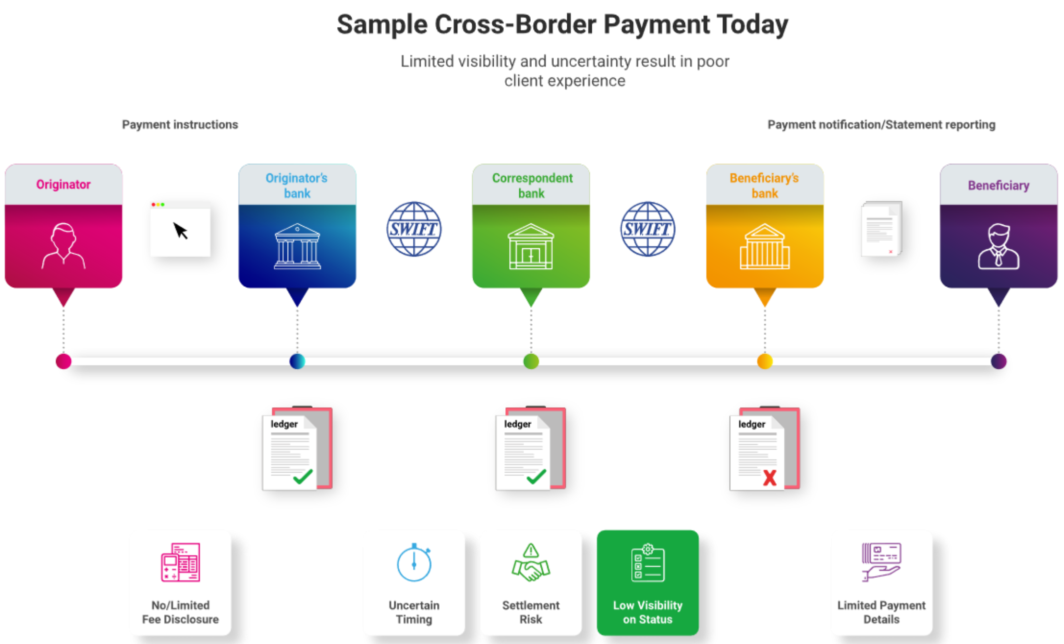


*Figure 1: How Blockchain can improve upon international payments inefficiencies (Ripple, 2016).*

Distributed Ledger Technology (DLT) introduces a different logic for validation, settlement and record-keeping. DLT provides a promising prospect to modernize payment services. This technological evolution has triggered changes in market demands, inviting financial services incumbents to innovate and enhance time and cost efficiencies. Many financial services and technology giants have already started collaborating to use blockchain for improving payments and the banking sector. Table 1shows several blockchain projects from several different financial services entities.

| Entity | Product Type | Application |
|---|---|---|
| **Mastercard** | **Blockchain-based API** | Ability to send money over a blockchain and provenance of luxury goods. |
| **R3** | **Corda** | Payments for instant Transfers. |
| **Ripple** | **Native Blockchain** | Exchange Network. |
| **SWIFT** | **As Proof of Concept (PoC)** | Reconcile their international accounts in real-time, optimising their global liquidity. |
| **J.P. Morgan** | **Interbank Information Network** | Blockchain payments network to respond to compliance and other payment delays. |
| **Libra Association** | **LibraCoin** | P2P transfer of money using the underlying Libra coin. |
| **Bank of England** | **RS Coin** | Bitcoin-like digital currency that works in a much more centralised way. |
| **IBM** | **IBM Blockchain World Wire** | Clearance and Settlement of cross-border payments. |
| **Mizuho Bank** | **J-Coin Pay** | Digital currency platform acting as a bank. |

*Table 1: Several blockchain and DLT initiatives from the financial services sector*

Use of blockchain technology to resolve inefficiencies in payment and clearing and settlement methods (Karaindrou, 2017), will give us a payment network fit for the modern era. Potential benefits of using DLT are:

- **Lowering transactional costs**: currently, the average processing fee for a Bitcoin transaction is 0.04 cents (other blockchain networks have even lower fees than this), compared to more than 0.35 cents for a typical credit card transaction.
- **Replacing cumbersome back-office procedures with DLT:** in existing payment networks and infrastructure (regardless of whether the network is centralized or decentralized) record keeping is part of several bank-client relationships. Records are duplicated amongst multiple intermediaries. These records get reconciled through back-office procedures which introduce the risk of discrepancies or time lapses, leading to double-spending of the same asset. A DLT based solution enables peer to peer sharing of data reconciled against a single version of the truth.
- **Speed across the value chain:** reducing reconciliation procedures and enhancing data processing capabilities may lead to more transactions settling in real-time.
- **Fraud Detection capabilities:** deceiving payments or tampering with contracts is highly unlikely and too costly to garner profits. The existence of an immutable ledger makes tracking of transactions in real-time very efficient.
- **Automated contract tools:** DLT has the programmability to be coupled with self-executing applications via smart contract applications. Self-executing transactions will minimize cost, maximize time efficiency and eliminate human error. Moreover, they will secure the enforceability of financial agreements stored on the ledger.
- **Better KYC and Identity Management:** cross border transferable data about customers and real-time intelligence sharing eliminates possibilities of fraud.

- **Better Identity Management:** current identity management systems have many inherited privacy and security problems, especially for end-users. Blockchain and DLT may be the solution to these problems. Cryptography and other cryptographic primitives that preserve privacy, such as zero-knowledge proofs, bring the notion of Self-Sovereign Identity (SSI). Entities that need to verify other users' information can do so without necessarily keeping track and storing their data.
- **Automated Compliance and Regulation:** automated compliance is beneficial to integrate into organisations that process such data such as banks and governments. Regulation and can offer many benefits which include less time needed and cost compared to manual controls. Compliance status and audit information can be accessed and checked within a single ledger, and in real-time. Risk management decisions can be made based on real-time data. DLT can also reduce compliance fines, breaches and inaccurate reporting mistakes. Finally, DLT can, importantly lead to continuously verifiable compliance requirements.

Major players in the payments, clearing services, settlement services and central banks are investing in DLT envisaging high-tech, resilient and time-efficient payment systems. However, since the technology is still maturing, there are significant challenges for global use of blockchain by the banks. These challenges are:

- **Scalability:** blockchain has a global transaction limitation.
- **Privacy:** in the choice between public vs shared ledger, privacy-preserving technologies such as ZK-SNARKs, MixNets and Zero-Knowledge Proofs (ZKPs) can be used to hide information regarding transactions meaning possibilities for money laundering might arise.
- **Interoperability:** blockchain requires everyone to use a single ledger, and still there is no standard data schema or protocol for the many moving parts of a blockchain such as consensus and validation.
- **Regulation:** usage of digital assets for transaction purposes with an appropriate framework.

## Towards efficient and automated M2M transactions

*"The blockchain is custom-made for decentralizing trust and exchanging assets without central intermediaries. With the decentralization of trust, we will be able to exchange anything we own and challenge existing trusted authorities and custodians that typically held the keys to accessing our assets or verifying their authenticity" (Mougayar, 2015).*

The Machine to Machine (M2M) connections market is predicted to reach $27 billion by 2023, at a CAGR[1] of 4.6% from 2017 to 2023 (Markets and Markets Research Report, 2017). The number of M2M connections was 1.47 billion in 2016 and is estimated to reach 3 billion by 2023. The major drivers for growth are the massive adoption of the Internet in emerging economies, as well as the rapid developments in Internet-of-Things (IoT) infrastructure.

The whole idea of IoT is a set of connected devices acting autonomously, communicating amongst themselves on a global scale and operating in an automated way eliminating human intervention as much as possible. IoT is on a path to changing the way we live and will have a significant impact on our daily activities. From homes that self-regulate temperature for our comfort to cities operating autonomously for efficiency and safety using smart technologies such as intelligent traffic lights, smart

[1] CAGR – Compound Annual Growth Rate

routing algorithms, etc., the value of IoT appears to be never-ending. The future has already come: many in-home devices are already connected to the Internet and help automate routine tasks.

However, there are still many challenges to be addressed before more massive adoption such as interoperability issues, untrusted communication paths, data protection concerns and cybersecurity issues. A considerable problem is that of payment networks since we would like to achieve complete automation and self-execution. This means that any monetary rewards or payments need to be in real-time and not over two to three days (as it usually is now). Such payments need to be of a minuscule cost as they are going to be microtransactions for the majority of cases.

In 2017, according to analysts at Gartner, there were an estimated 8.4 billion IoT devices. By 2020 that number could exceed 20 billion, and by 2030 there could be more than 500 billion. The implications of this revolution in connectivity extend far beyond just smartphones and private houses. IoT is about to be applied on a much larger industrial scale to everything from fridges to farming to healthcare, in a manner people can hardly imagine.

IoT, in conjunction with blockchain technology, is expected to rise even more due to the capabilities of conducting automated and self-executing transactions. Smart contracts can encode conditions, agreements and constraints and automatically execute them when certain assumptions become valid.

Merging IoT and blockchain we can create a verifiable, secure and permanent method of recording data that could be processed by “smart” machines in an automated, transparent and self-executing way. This network of interconnected devices will be able to interact with their environment and make decisions without any human intervention by the deployment of smart contracts.

Data-driven technologies such as Machine Learning (ML) and Artificial Intelligence (AI) can be deployed in parallel to create high accuracy predictions about conditions and constraints encoded into smart contracts. These technologies can also predict the “status” of the network and activities with very high accuracy. Predictive capabilities will allow the automation of procedures and proactiveness.

As a result of the exponential increase of IoT interconnected devices, M2M payment solutions are the next logical step (Markets and Markets Research Report, 2017). When applied to M2M, AI and ML enable systems to communicate with each other and make their own autonomous choices (based either on hardcoded conditions or conditions predicted with very high accuracy by AI algorithms). Smart contracts will significantly reduce the costs of formalising, agreeing and enforcing contracts and making payments. Autonomous agents (bundles of smart contracts) on the blockchain hold the promise of eliminating agency and coordinating costs and can perhaps even lead to highly distributed enterprises with little or no management.

Billions of IoT devices are connected all over the world, and it won’t be long before almost all of our devices and technologies are connected through IoT protocols. M2M payments can include a multitude of scenarios, like transactions based on customer behaviour without our knowledge, health and financial diagnostic tools and many others.

Blockchain is much more than a decentralized ledger and can be considered as a highly secure and trustworthy data bus. Participants in a blockchain network can trust the data transmitted through the blockchain and transaction signing allows verification of the source and integrity of the data. This means that we can be sure where data comes from and that it has not been modified in transit. Blockchain and DLTs solve significant challenges in the data science lifecycle that include:

- A lack of proper data governance;

- A lack of data definition and storage protocols: data is poorly defined, confusing the appropriate methodology for management. We thus miss many opportunities as in many cases different data sources cannot be combined in a data analytics project;
- A lack of data security procedures resulting in corrupted or modified data;
- Too much data that is not useful stored in multiple sources under different schemas;
- Inconsistent data recorded using different procedures and protocols: inconsistency is a significant indicator that there's a data quality problem;
- Incorrect data recorded with no formal procedures;
- Poor data recovery capabilities.

As we know, no statistical argument can save lousy quality data, and blockchain is an intermediate step that guarantees the authenticity of data. This is known as Garbage-In Garbage-Out (GIGO) in computer science language. Blockchain enables us to solve all the above issues as the data encoding, and data transfer protocols are hardcoded into the global public network. Data is written in the decentralised database after the approval of the whole network via hardcoded and transparent consensus algorithms. Thus, data quality is guaranteed, and hence the potential of AI and ML algorithms are much more significant as the data are correct and trustworthy.

Blockchain technologies, such as smart contracts, present a unique interface for M2M communication and provide a secure, append-only record that can be shared without trust and a central administrator (Hanada et al., 2019). Smart contracts are a real game-changer for IoT applications.

Through encoded logic, it is possible to create agreements which will be executed when certain conditions and constraints are met. This is extremely useful for all sorts of scenarios. A most basic example is that you can authorize payment when circumstances indicate that delivery of a service has been provided. Here all interactions between a consumer and their connected devices (or indeed inter-connected devices) are handled in a transparent, tamper-proof, immutable and frictionless way.

Furthermore, blockchain might come with a built-in cryptocurrency which can provide a way for participants to engage in economic transactions in an incentivised way. Thus, the blockchain should give the ideal backbone for connected IoT devices to securely exchange data and interact autonomously in an M2M economy.

For example, a smart contract can guarantee discounts to electricity bills or rewards via inbuilt tokens for a smart house appliance system that shows better performance in consumption of underlying interconnected machines or increased use of renewable energy. Below are a few examples of applications of M2M connections by end-users (Markets and Markets Research Report, 2017):

- **Healthcare:** Many applications in this sector are expected to appear such as patient Monitoring Systems, Fall Detectors, Smart Pill Dispensers, Telemedicine and many others. All these devices will be interconnected, and data will be streamed to doctors (enabling proactive measures as well). Blockchain can be used to ensure that data are released with the permission of the data owner but also that the data quality, which is of great importance in this case, will be guaranteed. M2M connections could potentially be utilized in hospitals to administer medications intravenously to patients whose vitals fall below a certain level.
- **Utilities:** Applications such as Smart Grids and Smart Meters. There are lots of blockchain applications; in this case, incentivisation built into the network for promoting the use of more efficient machines, decreasing power consumption and increasing renewable energy use.

- **Automotive & Transportation:** Telematics, Fleet Tracking/Monitoring, Supply chain capabilities, sourcing capabilities.
- **Retail:** Intelligent Vending Machines, Contactless Checkout/Pos, Digital Signage and automated ordering. Better loyalty schemes can be built using blockchain technology but also the full tracking and sourcing of food lifecycles will be available and transparent. One of the most basic uses of M2M would be a vending machine autonomously contacting its distribution company when its supplies have fallen below a certain point.
- **Consumer Electronics:** Smart TVs, Smart Appliances, Smart Refrigerators, Smart Washing Machines, Smart Ovens and Smart Cooktops.
- **Security & Surveillance:** Commercial & Residential Security and Remote Surveillance with automated intelligence sharing.

Blockchain can significantly improve all the applications mentioned above as its integration will guarantee transparency, self-execution and speed. It will provide a method for incentivising the desired actions into an ecosystem via tokenisation.

The widespread use of the internet in the 1990s changed the way we communicate forever. More than 30 years later, this technology, which seemed so foreign at its beginnings, has become an integral part of our daily lives. IoT paired with blockchain technology, is laying the groundwork for the next step in information and technological evolution.

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## Part B: Consensus: Proof-of-Work, of-Stake and Structural Alternatives

*Nicola Dimitri*

The blockchain version implemented by Bitcoin is based on a consensus mechanism called Proof-of-Work (PoW) (Narayanan et al., 2016; Antonopoulos, 2017). That is, nodes wishing to confirm a block of transactions and receive the related reward for it, need to solve a cryptographic puzzle that requires the use of computational power. Those trying to solve the problem, so-called *miners*, compete with each other to *come first* in proposing the solution, and such competition has currently led to massive energy consumption by the Bitcoin community. The central intuition behind PoW is conceptually deep, though simple to understand. Nodes willing to compete to confirm blocks of transactions must spend resources to do so. In return, nodes have a strong incentive to keep the system going correctly, limiting malicious attacks to the system.

The incentive would be even stronger if the resources invested in *mining* are, *sunk costs*, that is, expenditures that are entirely dedicated to that goal and with no utility for other goals. However, on the other hand, such meaningful expenditure is perceived by many as a waste, since it supports high energy consumption to solve a puzzle, with no immediate benefit for society as a whole.

However, because of this very high energy consumption, as well as issues related to scalability and speed, in recent years, concerns on the sustainability of blockchain models based on PoW have emerged. This led to several alternative DLT models, differing on some elements from blockchain frameworks inspired by Bitcoin.

To try solving or mitigating blockchain problems related to energy consumption, scalability, security and speed, an alternative class of DLT structures have emerged. One such structure is based on Directed Acyclic Graphs (DAG). Latora etal., (2017) proposed DAG structures appear in other contexts, such as citation networks (Goldberg et al., 2015) and are thought to represent a possible solution to blockchain-related problems. Unlike blockchains, with DAG, data are not stored in an ordered sequence of blocks, where each of them has limited capacity, but rather in a single block/ledger with no pre-specified capacity limit.

An interesting example of how data approval and storage work with DAG is the IOTA cryptocurrency. IOTA was founded in 2015, aiming to solve some of the problems that emerged with Bitcoin.

### IOTA and Tangle

The first problem is related to energy consumption, which would be heavily reduced by eliminating the Bitcoin distinction between miners and users. Indeed, in IOTA, each node of the network *can be both a miner and a user*. In IOTA, there is virtually no energy expenditure for approving transactions.

In IOTA the sequence of blocks is replaced by the so-called *Tangle* (Popov, 2018), which is the set of transactions executed in IOTA from the start, a term which evokes the idea that approved transactions are not organized in blocks. Indeed, the underlying structure of the *Tangle* is minimal and represents the underlying nature of the DAG in IOTA. This structure is given by a set of nodes and a set of directional links, each of them connecting one node to a pair of nodes.

Below we discuss the interpretation of nodes and links in the *Tangle*. In the *Tangle,* each node in the network can be both a miner and a user. As a consequence, unlike Bitcoin, no significant energy consumption is required for approving transactions. More specifically, transaction approval works as follows. Except for the initial distribution of tokens, any new transaction, called a *Tip*, wishing to join the *Tangle* needs to approve a pair of transactions which already appear in the ledger.

Therefore, nodes in the *Tangle* represent transactions, while direct links connecting one node to two nodes represent approvals. However, when a *Tip* approves a transaction in the *Tangle,* it does not establish its definite validity. Together with other received approvals, it brings a contribution to the validity of that transaction. Approving a transaction can be seen as analogous to voting for that transaction: the higher the number of obtained approvals the more likely it is for a transaction to be valid and become a definite part of the ledger.

As in Bitcoin, transactions have time stamps which describe the time evolution of the system. However, perhaps more than for Bitcoin, in the *Tangle* a transaction timestamp is essential to understand the time evolution of the system, which is not organized in blocks.

The above description immediately clarifies why the *Tangle* has a minimal structure. Moreover, transaction approval does not require costly competition across miners. This makes IOTA suitable for small currency exchanges which, in Bitcoin, would offer low or no transaction fees for confirmation, that may delay or even prevent its insertion in a block.

As with other consensus mechanisms, the *Tangle* is not free from malfunctioning or malicious attacks. An example of a malfunction is when a *Tip* (a transaction which is in the *Tangle* but hasn't received approval yet), can remain without approval for a sufficiently long period (even when a Tip contains no double-spending or lacks approvals). A double-spending attack is also possible. This occurs when a transaction which contains IOTA units already spent in other transactions is approved. Strategically this occurs through several small monetary transactions being performed deliberately by the attacker. These small transactions are valid and can correctly provide a sufficiently large number of acceptable approvals to an invalid transaction.

The above two examples should suffice to illustrate that while DAG distributed ledgers such as IOTA can solve some of the problems related to blockchain systems inspired by Bitcoin, they can still be prone to structural problems and malicious attacks.

**Proof-of-Stake**

To save on energy spending and speed up transactions, as compared to Bitcoin, one of the ideas, recently under investigation, is to consider DLT consensus procedures other than PoW. A variety of consensus procedures have been put forward (Wang et al., 2019), and in this section, we discuss several of them. As well as PoW for Bitcoin, the analysis of consensus procedures is essential because of the possible consequences on how systems work and function correctly, in the short and long run.

Currently, the main alternative to PoW is Proof-of-Stake (PoS). In Bitcoin, blocks enclose confirmed transactions. The original idea (Bentov et al, 2017; Narayanan et al., 2016) underlying PoS was the following. A user will be randomly selected by the system, with a probability that is proportional to his wallet *coinage,* to confirm the next block. The *coinage* of a currency unit is given by the number of blocks which the unit has been unspent for. The *coinage* of a wallet is given by the sum of the coinage of each unit in the wallet. For example, let's take a user who owns two currency units in his wallet. One hasn't been spent for three blocks and the other for four blocks. In this case, the wallet *coinage* is equal to seven. Once a unit is spent, and transferred to another wallet, its coinage becomes zero, until it remains unspent in the new wallet for some blocks again.

PoS (BitFury Group, 2015) was proposed initially in 2012 by the *Peercoin* cryptocurrency (Bentov et al, 2017) in a *hybrid* version where PoW was also present. Here mining of a block is still based on solving a cryptography puzzle by means of PoW; however, the difficulty is inversely proportional to one's wallet *coinage*. Therefore, in this mixed PoW-PoS framework, a lack of computational power could be replaced by a high value of coinage, potentially saving energy consumption. Such a system would provide an incentive first to spend currency units with a lower coinage, and then those with a higher coinage. However, this behaviour may lead to infrequent transactions within the community, where individuals could be more interested in storing money (to increase the probability of getting additional units in the future) than exchanging it. As a result, the blockchain system could end up becoming like a lottery, with currency units playing the role of lottery tickets.

More recently, further PoS versions have been proposed (Kiayias et al., 2017). *Coinage* has been eliminated in the PoS version adopted by *Blackcoin* (Vasin, 2014). Emerging platforms such as Algorand (Chen & Micali, 2019) as well as more established platforms like Ethereum (Buterin & Griffith, 2019) are thinking of using PoS as part of their consensus procedures.

Interestingly, the PoS version adopted by Algorand is reminiscent of rotation criteria adopted in the Medieval Communal age. Here political and administrative officials were periodically changed to prevent the emergence of dominant and autocratic positions. As we shall see, in Algorand rotation applies to proposers of blocks.

In Algorand, PoS operates by randomly selecting users to play a particular role. For example, users could be selected to propose a new block of transactions. Alternatively, they could be selected to be part of a Committee which votes on some specific issue. This is PoS because users are randomly drawn with a probability that is positively related to the number of currency units they own. More specifically, if $A$ is the total number of currency units in the system, called *Algo* in Algorand, and $a$ is the number of units owned by a user, then $p = \frac{a}{A}$ is the probability with which such a user would be selected to take a given role.

Those individuals with a higher stake are more likely to be selected and re-selected. Therefore, to prevent frequent re-selection as well as malicious activity against committee members, once a user has been chosen, he could not be re-selected for the next few rounds. To discourage opportunistic behaviour and attacks against committee members, each member knows whether or not they have been selected. This is possible through Verifiable Random Functions (Micali et al., 1999).

The replacement of PoW with a consensus procedure based on PoS has been under discussion within the Ethereum community since the start of the platform. The new consensus mechanism is called Casper, and like Algorand is based on the assumption that $\frac{2}{3}$ of the users behave honestly. This assumption is to say that if less than $\frac{1}{3}$ of users engage in adversarial behaviour the system can keep functioning correctly. This is the Byzantine Fault Tolerance (BTF) threshold of the system.

Ethereum's proposed PoS also contains a feature on how to solve the *nothing at stake* issue, that may lead to malicious attacks. This issue could occur under PoS since, unlike PoW, obtaining currency units is not expensive, and their duplication is costless. For this reason, the main elements of Casper, whose final version is not complete, have been designed as follows. As well as in Bitcoin and Algorand, validated transactions are stored in a blockchain. However, unlike these platforms, to speed up and scale block validation, this is not performed block by block, but periodically after a predefined number of blocks. Validation takes place at blocks called *checkpoints*. Any user with even a minimal amount of currency units can be a validator.

Validators can obtain some currency units if the block they propose is approved. However, to prevent the *nothing at stake* problem, a validator has to deposit a certain sum of currency units, which represents their stake in the system. PoS comes into action here. A validator can then cast a vote on which blocks to approve with their *stake*, over the total number of deposited units in the community.

If the proposed block violates two specific Casper rules (inserted to avoid forks in the chain and double-spending), then one's *stake* would be *slashed* immediately upon detection of the attack and lost.

Therefore, the deposit corresponds to the penalty imposed on attackers for adversarial behaviour. It is interesting to note that when choosing the size of the deposit, a potential attacker faces a trade-off. The trade-off is that the larger the stake, the higher the probability of approving a specific block, (which contains a double-spending transaction) but the larger the penalty in case their dishonest behaviour is discovered. Therefore, slashing deposits with Casper can effectively deter attacks to the Ethereum blockchain if attackers are detected in time.

Adoption of PoS drastically reduces electricity consumption when compared with PoW. However, consensus and monitoring procedures have to be effective in preventing more than $\frac{1}{3}$ of the users from being able to attack the system.

Let us consider a simple numerical example to understand how Casper works. Suppose a user owns $100$ *Ether* (the Ethereum currency). Moreover, suppose he decides to build a deposit with $0 \leq d \leq 100$ of them. These $d$ Ether would be the user's *stake*. Furthermore, assume the rest of the community deposited a total of $1000$ Ether. When determining how large $d$ should be, the user can think in terms of the following trade-off. Suppose the user proposes a block that contains a double-spending transaction and whose value corresponds to $x$ Ether. Suppose $p$ is the probability of the block being detected once approved and $r$ the reward obtained in case of a block approval. Also, suppose that $D$ is the size of the deposit of the users who are expected to vote for that particular block. With these assumptions, the user's utility $U_a(d)$, in case he attacks, will be a random variable defined by

$$U_a(d) = \begin{cases} 100 + (x + r) & with\, probability (1-p)\dfrac{(d+D)}{1000} \\ 100 & with\, probability\ 1 - \dfrac{(d+D)}{1000} \\ 100 - d & with\, probability\ p\dfrac{(d+D)}{1000} \end{cases}$$

and his expected utility will be defined by

$$EU_a(d) = 100 + \frac{(x+r)(1-p)(d+D)}{1000} + \frac{(100-d)p(d+D)}{1000} \quad (1)$$

Differentiating (1) with respect to $d$ and equalising to zero provides the optimal value of the deposit $d_a$ maximising (1), as defined by

$$Max(0, Min(d_a = \frac{(x+r)(1-p)}{2p} - \frac{D}{2} + 50, 100)) \quad (2)$$

Interestingly, the value of (2) increases with $x$ and decreases with $D$ and $p$. Therefore, the value of $d$ given by $(2)$ is larger than $50$, half of the available currency units, if

$$\frac{(x+r)}{D} > \frac{p}{(1-p)} \quad (3)$$

that is if the ratio $\frac{(x+r)}{D}$ is larger than the *odds* ratio $\frac{p}{(1-p)}$ . It is also interesting to observe that expression (1) clearly shows the trade-off faced by a user when choosing the deposit size. Indeed, the term $\frac{(100-d)p(d+D)}{1000}$ on the right-hand side of (1), being quadratic and concave in $d$, first increases and then decreases. Intuitively this means that, typically, the utility maximising deposit should be *neither too small nor too large*.

If, instead, the user behaves honestly then his utility $U_h(d)$ would be equal to

$$U_h(d) = \begin{cases} 100 + r & with\ probability\ \ \frac{(d+D)}{1000} \\ 100 & with\ probability\ \ 1 - \frac{(d+D)}{1000} \end{cases}$$

and his expected utility would be

$$EU_h(d) = 100 + \frac{r(d+D)}{1000} \quad (4)$$

It follows that since (4) is linear in $d$, it would be maximized by $d_h = 100$, that is the entire available sum hence the maximum size of the deposit. This observation is consistent with one's intuition. Indeed, if the user is planning not to attack, then by depositing his entire available sum, they will maximise the probability of being selected to confirm the next block while running no risk of losses.

A user will consider attacking the system if when replacing (2) and $d = 100$, respectively, in (1) and (4), the former will be larger than the latter. One can notice that if $d = 100$ then expression (2) becomes

$$EU_a(d = 100) = 100 + \frac{(x+r)(1-p)(100+z)}{1000}$$

which can be larger than (4) if $\frac{x}{r} > \frac{p}{(1-p)}$.

**<u>Proof-of-Burn</u>**

Proof-of-Burn (PoB) is also another consensus protocol worth discussion. PoB is currently adopted by cryptocurrencies with limited capitalization. The first and best known of them is Slimcoin (2014). The goal of PoB is analogous to PoS, to propose a consensus procedure solving the energy costs associated by PoW while, at the same time, reducing the possibility of attacks. As well as PoS, PoB is a consensus mechanism based on currency units held by users. However, unlike PoS, validation of a block and related reward are based on a *burnt* number of currency units by a user $b$ . Operationally, burning some units would mean to send them to an address which nobody can use. Continuing with the previous example, if a user has 100 units in his wallet, then before validating the next block their utility level is a random variable defined by

$$U(b) = \begin{cases} 100 + r - b & with\, probability \;\; \frac{b}{1000} \\ 100 & with\, probability \;\; 1 - \frac{b}{1000} \end{cases}$$

and therefore

$$EU(b) = 100 + \frac{(r-b)b}{1000} \quad (5)$$

so that the optimal $b_o$ is given by

$$b_o = \frac{r}{2} \quad (6)$$

That is, the optimal number of currency units to burn are half of the reward obtained by the user, in case they are selected to validate the next block. Inserting (6) into (5) the expected utility becomes

$$EU(b_o) = 100 + \frac{r^2}{4000}$$

which implies that with PoB, the user's expected utility is larger than $100$ and grows quadratically with the reward for block validation. If the above analysis is an acceptable description of what might happen with PoB, and if $r$ is a relatively small reward, then $b_o$ is also a small sum.

DLTs are an area still rapidly evolving and continuously changing. The aforementioned discusses how DLT may develop from the perspective of consensus mechanisms. Starting from Bitcoin's PoW and moving on to DAGs, PoS and PoB. By the time the contents of this section become available, they may already be partially obsolete. Nevertheless, the author hopes the material can still help readers to navigate the fascinating area of DLT.

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# Chapter 2: Defining the Internet of Value

*Horst Treiblmaier*

The term "Internet of Value" has had many meanings ascribed to it. In this section, Horst Treiblmaier seeks to define what this term means, looking at previous definitions and elucidating on what properties an IoV may have. One may ask why it is important to come to a definition of what the term IoV means. The blockchain and distributed ledger technology world have suffered from a lack of coherence in a common language used to describe properties in the field. By striving to create a better taxonomy and ontology, it makes it easier for stakeholders to communicate with more precise meaning – hopefully enabling faster progress and development.

The section begins by looking at the development and evolution of the Internet and the rise of blockchain. It then moves on to look at various definitions of the IoV noting that blockchain is the commonality between all of them. A definition of the IoV is suggested as "*The instant transfer of assets that can be expressed in monetary terms over the Internet between peers without the need for intermediaries.*" The attributes of an effective IoV are described and what enablers of its development could be. Finally, this section finishes with a high-level look at the economic impact that the IoV's successful enablement could bring.

This section was reviewed by Paolo Tasca and Nikhil Vadgama.

**From the Internet of Information towards the Internet of Value**

The internet was conceived as a technology to enable communication via computers in the case of a partial network disruption, as might happen during a military conflict. It soon turned out that packet switching networks, in which data are flexibly routed via intermediary nodes, have numerous advantages over circuit switching in which a dedicated communication channel is established before the start of a communication. The Transmission Control Protocol/Internet Protocol (TCP/IP) emerged as a protocol suite that includes four distinct layers, namely link (sometimes split into physical and data link layers), network, transport and application. Those layers implement the functionality which is specified in the 7-layer Open Systems Interconnection (OSI) model and form the basis of the modern Internet.

The HTTP (The Hypertext Transfer Protocol) is part of the application layer and provides the foundation for the World Wide Web (WWW). Over the years, it has been proven to be a robust protocol which is capable of handling data requests. One of its significant shortcomings, however, is the fact that it is stateless. The term stateless refers to the fact that HTTP servers by default do not keep session information. Each message being sent is understood in isolation. A stateful protocol, in comparison, sees a single data packet as part of an overall communication. Simply put, such a protocol can answer questions such as “who is who?”, “who owns what?” and “who has the right to do what?” (Voshmgir, 2019).

Interestingly, the specification of HTTP includes a status code (402: “Payment required”) which is reserved for future use and indicates that the necessity of monetary transfers was recognised early by the developers of the protocol. However, for many years no technology existed to implement such a functionality.

It did not take long before the potential of the Internet for doing business was discovered. With the emergence of electronic commerce, the shortcomings of a stateless protocol soon became even more apparent. Sessions (“server-side cookies”) and cookies were used to keep track of ongoing and previous communications. In the case of sessions, data are stored on the server in an encrypted form and allow for secure communication. Cookies on the client side are stored by the web browser which sends them back to the server, creating a memory of previous events. Sessions and cookies enabled the WWW to become “stateful”. This offered new opportunities for businesses and customers but also led to the emergence of powerful intermediaries which are monitoring and directing communication, transactions and gathering vast amounts of data. The WWW has also turned into a platform for social exchange. A handful of dominating platforms have emerged due to network effects, which postulate that the value of a network increases with the number of its users.

As a result, Internet users turned from consumers into producers of information through posting content online and simply surfing the WWW, leaving numerous traces of online behaviour behind. Additionally, sessions and cookies made it possible to transfer payments through dedicated organisations, which not only monitor and potentially also control transactions but also charge fees for their services. This led to a situation in which a few powerful intermediaries emerged that are in charge of value transfer over the Internet. These organisations include credit card companies, which successfully transferred their business models from the real world into cyberspace, and new market entrants who tailored their business models to the capabilities of the Internet. However, the full potential of the Internet did not materialise. In spite of the fact that modern networks allow for almost instant data transmission, in 2017 a typical international payment in the United States took 3-5 days to settle, had an error rate of more than 5% and an average cost of $42. On a global basis, cross-border payments amounted to $180 trillion yearly, with a combined cost of more than $1.7 trillion (Polishchuk, 2017).

The Bitcoin protocol, which was introduced in 2008 and implemented in 2009 by the pseudonymous author Satoshi Nakamoto cleverly combined numerous existing technologies and, for the first time, solved the problem of online “double spending”. Bitcoin is a decentralised network that achieves consensus without a pre-specified governance structure. In other words, one specific Bitcoin (or an arbitrary part thereof) can be owned by only one particular address at any specific point in time. Being a decentralised platform does not mean that Bitcoin lacks any form of governance, but rather that it does not depend on particular authorities in a rigid hierarchy. Instead, a consensus is reached between stakeholders such as developers, miners (mining pools) and validating nodes, all of whom can individually decide on entering or leaving the system.

At its core, the Bitcoin protocol allows for the transfer of a cryptocurrency. The value of a bitcoin is determined by the supply and demand of its users and is not backed by any other asset. The maintenance of the system is done by miners who are incentivised by gaining cryptocurrency for the provision of computing power. Other than in existing payment systems, no central authority exists that determines costs, monitors transactions or restricts access.

Since Bitcoin’s inception, it has not taken long for the identification of numerous use cases beyond cryptocurrencies and for the technology to gain widespread popularity. Numerous so-called Altcoins have emerged, modifying the source code of Bitcoin and adding additional functionality. Everything that can be mapped onto a digital asset can be transferred via a blockchain-based solution. On top of the Bitcoin blockchain, so-called coloured coins were used to represent real-world assets, but the limitations of Bitcoin’s scripting language soon triggered the quest for more robust solutions. As a result, blockchain platforms such as Ethereum were developed with the goal of increased flexibility through the availability of a fully-fledged programming language. More and more functionalities were integrated into so-called tokens that can be easily transferred on the network and represent an asset. The term “tokenisation” thus refers to the transformation of asset rights into digital tokens that can be easily traded on secondary markets. In the offline world, this corresponds to the well-established financial practice of securitisation by which different types of contractual debt or illiquid assets, such as mortgage or auto loans, are bundled and sold to third-party investors.

**A definition of the “Internet of Value”**

No unambiguous definition so far exists for the term “Internet of Value”. At its core, it means that the Internet, a collection of protocols to transfer information in the form of bit and bytes over different physical media, can be used to transmit assets that can be expressed in monetary terms.

In the context of blockchain the term “Internet of Value” was mainly popularised by Ripple, a technology company developing a distributed system for settlement, currency exchange and remittance. In table 2, we list several definitions of the “Internet of Value” as found in company reports and academic papers. The core feature of all definitions is the capability of blockchain to facilitate the exchange of digitised assets among peers.

| | |
|---|---|
| [The Internet of Value is] a kind of trusted protocol that could, amongst other things, provide a notarial function for all transactions carried out on the web, automated and transparent for all. | (PricewaterhouseCoopers, 2016) |
| With the Internet of Value, a value transaction such as a foreign currency payment can happen instantly […]. The Internet of Value will enable the exchange of any asset that is of value to someone, including stocks, votes, frequent flyer points, securities, intellectual property, music, scientific discoveries, and more. | (Polishchuk, 2017) |
| The Internet of Value refers to an online space in which individuals can instantly transfer value between each other, negating the need for a middleman and eliminating all third-party costs. | (Finance Monthly, 2018) |
| [Internet of Value is a] platform of the next-generation Internet that enables various types of assets to be digitised and represented as digital values, and directly and securely exchanged using Blockchain. | (Truong et al., 2018) |

*Table 2: Definition of the "Internet of Value"*

The meaning of the term "value" has been fiercely debated among philosophers since the days of the ancient Greeks. A common distinction is made between intrinsic and extrinsic value, with the former, especially in a business context, often seen as the value that can be determined through fundamental analysis without referring to the actual market value. This distinction on value is not crucial for moving towards a definition of the IoV. The crucial issue is that blockchain is capable of creating digital twins, which are digital representations of objects from the physical world, including human beings but mostly things and intangibles such as processes or systems. These digital twins can be expressed in monetary terms such that a certain value is assigned to them.

Blockchain technology facilitates the transfer of these digital representations with the help of asymmetric cryptography. By generating a pair of keys, one of which is public and the other one private, users can create certificates to prove the ownership of a digital asset. They can easily transfer them to other addresses instantaneously. The moment the transaction is validated by the network and written into the blockchain, control over the asset has shifted to the new owner. This validation process was previously done by third party institutions such as banks. Here banks are an intermediary facilitating the transfer of value. Other examples for intermediaries include brokers, agents or merchants. It is therefore likely that the role of existing intermediaries will change and new intermediaries will emerge who take over tasks such as identity verification or quality assurance of physical property.

Notwithstanding the importance of these tasks and others that might emerge with the more widespread use of the technology, intermediaries are not needed for the actual transfer of digital assets. Summarizing, we define the Internet of Value as follows:

*The instant transfer of assets that can be expressed in monetary terms over the Internet between peers without the need for intermediaries.*

A somehow related term is “Internet of Things” which describes where the Internet is used as a medium for data exchange for objects in the physical world. Smart objects are computing devices equipped with positioning and communication technologies that communicate with each other over the Internet without the need for any human interference. The Internet of Things, therefore, refers to the communication of objects while the Internet of Value focuses on the addition of blockchain technology to create a layer for value transfer. The latter can be seen as an enabler for the former by enabling the interoperability and exchange of monetary assets without human interaction. The IoV can also enable micropayments, namely the transfer of small amounts of money that are only feasible in systems with low transaction costs.

**Core elements of the IoV**

One of the first attempts to specify what the IoV is stems from the W3C Web Payments Interest Group (2015). In their manifesto, they first state that many value networks exist and always will do so and that there are many ways to connect them. Furthermore, they identify several key attributes of the IoV such as the free movement of information, openness and availability for everyone, the existence of trust and security, simultaneous occurrence of privacy and transparency, absence of a single point of control, application of open standards as well as a simple and extensible underlying infrastructure.

They also refer to five core principles for open standards, as suggested by OpenStand, a movement to embrace principles for a modern paradigm of standards. These standards include the respectful cooperation between standards organisations, adherence to the fundamental parameters of standards development, collective empowerment to strive to develop standards that are chosen and defined based on technical merit, availability of standards specifications and, finally, voluntary adoption by the standards market (OpenStand, 2014).

Tapscott and Tapscott (2016, p. lxvii) explicitly mention that the IoV requires stewardship at three different levels. The first is that each platform needs to be able to govern itself. Second that standards need to be developed on an application level. Thirdly, on the ecosystem level networks and advocacy groups need to conduct research and spread knowledge. In table 3, we briefly summarize and explain these attributes.

| Attribute | Explanation |
|---|---|
| Value moves as freely as information | Blockchain/DLT adds a new layer to the Internet, which solves the double-spending problem. The transfer of information thus corresponds to the transfer of value. |
| Openness and accessibility | Blockchain/DLT allows the specification of the circle of users. In public blockchains, nobody is arbitrarily denied access to the Internet of Value. |
| Trust and security | Trust in intermediaries is substituted by trust in technology. This includes trust in the underlying infrastructure, the protocol and network governance. |
| The simultaneity of privacy and transparency | Blockchain/DLT-based solutions allow various degrees of anonymity. Concurrently they enable real-time access to shared data. |
| Not controlled by a single entity | Decentralisation and distribution of power are core features of blockchain/DLT. |
| Open standards | The Internet of Value is built on OpenStand's five principles of modern standards. |
| Simplicity and extensibility | The goals include an abstraction of key areas of complexity and the creation of a framework that supports existing systems while allowing for smooth transitions. |
| Self-governing platforms | Platforms need to be self-sustained by developing their ecosystems, standards and use cases. |
| Application-level standards | Standards on the application level established by consortia facilitate technology development and deployment. |
| Networks and advocacy groups at the ecosystem level | On an ecosystem level, support is needed to promote the technology and create awareness. |

*Table 3: Key attributes of the IoV (Tapscott and Tapscott, 2016, p. lxvii; W3C Web Payments Interest Group, 2015)*

In addition to the attributes in table 3, we identified several enablers of an Internet of Value, as can be seen in table 4. The digitalisation of value, namely the estimation of an asset's market valuation is a prerequisite to creating an economy in which assets can be represented by their digital counterparts such as tokens. Additionally, fundamental changes are needed within organisations, which pertains both to business processes as well as organisational structures. Existing management tasks, many of which are auditing and control functions, will potentially be replaced by automated procedures controlled by algorithms. Decentralised applications and DAOs allow for an unmediated exchange between objects, people and machines. The latter is enabled by M2M technology or communication. The IoV thus provides the payment layer for all ongoing initiatives in this area.

| Enabler | Explanation |
|---|---|
| Digitalisation of value | Processes to assess the market value of an asset and to put it into a digital format. |
| Organisational change | Organisations need to adapt their processes and structures. |
| Market transformation | Markets need to enable and accept the digital transfer of value. |
| Legislation | Government and supranational institutions must provide the legislative framework |

*Table 4: Enablers of the Internet of Value*

Importantly, markets need to transform and accept the fact that value is transferred via entries in decentralised databases. This not only pertains to activities related to business-to-business (B2B) but might involve all kinds of activities in which governmental institutions or private persons (e.g. as consumers) are involved. Finally, new and flexible legislation is needed, providing a framework adjusted to rapidly changing environmental conditions.

Herzog (2019) summarizes the mission of the IoV as follows: "to allow billions of people around the world to access an electronic wallet so that they can reclaim their financial freedom and exchange values without intermediaries". While this statement has a special focus on private individuals, we want to highlight the fact that businesses and public organisations can equally make use of a digitised exchange of value.

**Economic impact**

The addition of a stateful layer on top of the existing Internet protocol that enables the transfer of assets has significant economic repercussions pertaining to both governance issues as well as the overall structure of networks. The removal of intermediaries, in combination with increased information transparency, leads to a mitigation of the principal-agent problem. This pertains to situations where agents, who possess all relevant information, act in their own best interests rather than for those of the principals. The IoV helps to reduce this specific problem by applying smart contracts as well as by giving principals advanced options to monitor transactions. Similarly, increased transaction speed, as well as automation, will help to decrease transaction costs, namely all expenses related to making economic trades such as costs for search and information, negotiation, control and adjustment. From an organisational perspective, the IoV can help to create new forms of competitive advantage. Still, it might also disrupt existing organisational structures by automating complicated processes that previously demanded verifications and confirmations at different hierarchical levels (Treiblmaier, 2018).

Figure 2 shows a framework, as originally suggested by Iansiti and Lakhani (2017), which illustrates four adoption phases of foundational technologies differentiated by their degree of novelty as well as the amount of complexity and coordination needed. One example for a single-use case (see the lower-left corner of figure 2) on the IoV is the payment with a specific cryptocurrency such as Bitcoin. This use case mimics the functionality of existing payment systems and can be offered by individual companies, thus indicating a low degree of novelty and low complexity. In contrast, a localised service, such as processing transactions on a private ledger, is characterised by a high degree of novelty, as is the case when business processes need to be reengineered, and by low complexity and coordination effort, since only a small number of stakeholders are involved.

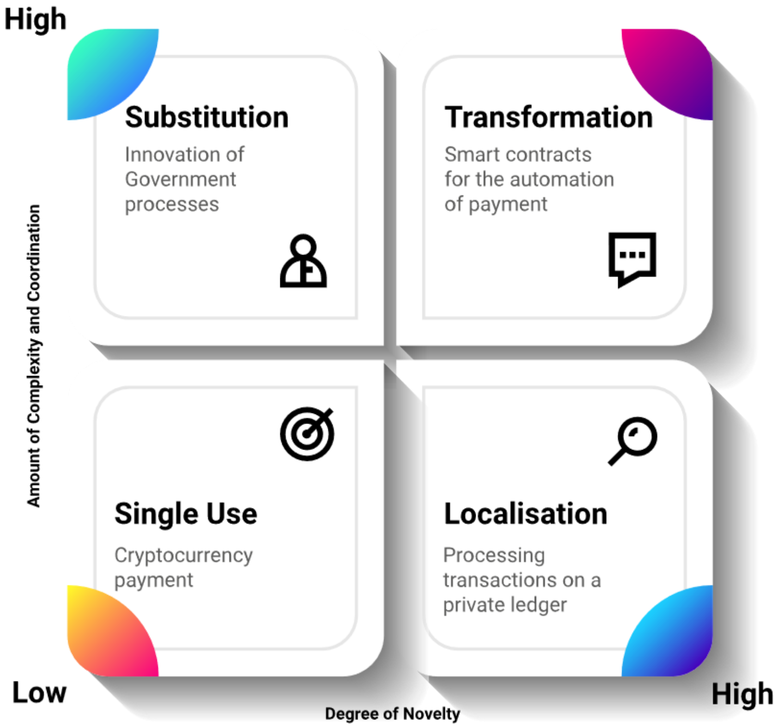


*Figure 2: Business transformation through the IoV (cf. Iansiti and Lakhani, 2017)*

Contrariwise, if existing services are substituted or supported by blockchain, the novelty might be low. Still, the complexity can be high, as is the case when government processes are innovated that involve numerous stakeholders. In such scenarios, blockchain might be used as a backend solution (e.g. blockchain as a service), and the complexity of the underlying processes might be unknown to the customers of the service (i.e. the citizens).

Finally, digital transformation can be reached by creating innovative solutions that span numerous processes and stakeholders. Smart contracts which automate payments in the supply chain can serve as a potential example that necessitates the involvement of different organisations and simultaneously a redesign of existing processes. Transferring value through automated decision procedures not only streamlines existing processes but might also conflict with the current legal system.

**Conclusions**

The numerous potentials of the IoV we outlined above do not imply that its further evolution is straightforward and easy to predict. Many unresolved issues remain, which include topics such as privacy, especially when sensitive personal data are involved. When it comes to security, Blockchain/DLT technology has specific advantages over centralised database technologies since it does not offer a central point of attack. However, this does not mean that attack vectors on different levels do not exist. Targets for attack could be users' wallets but also the network, mining pools or smart contracts. Besides, the technology is still under development and predictions are hard to make where the technology itself and also potential attack strategies are heading to.

A big unknown is the future adoption both from organisations and end-users. In this regard, the usability of applications will play a decisive role and support at different levels will be crucial to promote blockchain technology in many different applications. Finally, it remains to be seen how incumbent companies, especially those who mainly function as intermediaries in the value chain, will react to changes in market structures and the emergence of novel business models capitalizing on the easy transfer of value.

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# Chapter 3: The IoV and Financial Services

*Andy Yee, Hermann Elendner*

Many would agree that blockchain's biggest success to date is still its genesis creation. Bitcoin quietly made its mark in its early years with a cult following before becoming a phenomenon. Purportedly reaching prices near USD$ 20,000 at the end of 2017 and with a market capitalisation of over $300bn (CoinMarketCap, 2020), approximately the same as the GDP of Finland (World Bank, 2020) or the market capitalisation of JPMorgan (Yahoo Finance, 2020). Having been able to replicate a decentrailsed payments network without any central authority is something that few could have imaged this new technology could achieve.

However, many of the promises of Bitcoin as a payments network that could fuel the IoV have not been realised. Bitcoin, as the first iteration of blockchain networks has its flaws. New technologies that are being created seek to build upon its foundations and create the economic value transfer layer for the Internet.

In this section, how the IoV can impact the financial sector broadly, beyond payments will be explored. In Part A, Andy Yee looks at the various different forms of business models that could be fulled by blockchain underpinning the IoV in the finance sector, concentrating manily on Stablecoins. The first part opens with establishing a taxonomy of digital money that captures the major categories by issuer / actor types. Then it lays out the business models, motivations, and ideologies for each category. Finally, it finishes with presenting possible futures based on the dynamics of competition and interaction between these major issuer / actor types.

In Part B, Hermann Elendner looks at new business models to emerge within the financial services sector from the development of the IoV, concentrating on decentralised consesnsus. Elender breaks down his Part by looking at new business models that will develop based on decentralised consensus based on state, based on procedure and finally based on agency.

This chapter was reviewed by Mike Brookbanks.

## Part A: The IoV and New Business Models in Finance

*Andy Yee*

### Introduction

With the advent of blockchain, a tidal wave of change is coming to the world of monetary technology. Alongside Bitcoin's spectacular rise, there has been an explosion of other cryptocurrencies, stablecoins[2], corporate tokens, and sovereign digital currencies. In just a decade, Bitcoin's market capitalization has grown to over $150 billion. Including the hundreds of other cryptocurrencies that have emerged, the total market capitalization of cryptocurrencies is over $220 billion. A few years ago, stablecoins were launched with the objective of minimizing the price volatility of cryptocurrencies. Today, there are 54 live and pre-launch stablecoins with a total market value of $3 billion in 2019, up from $1.4 billion in 2018 (Blockchain, 2019). More recently, financial institutions and technology giants - the BigTechs (Frost et al., 2019) have entered the fray, with many of them announcing that they are exploring or launching stablecoins in their digital networks. Observing that this might be the early stages of a paradigm shift, many central banks are determining whether to redesign government-issued money into digital currency.

This part details new finance business models and the associated proliferation of digital currencies from the vantage point of Friedrich Hayek's classic work on monetary denationalization. In the *Denationalization of Money* (Hayek, 1976), Hayek argues that the state monopoly of money must be eliminated to prevent periods of inflation for the gain of governments. That, there should be free competition in money issued by public and private enterprises for consumers to determine the best possible option. The emergence of Bitcoin in 2009 sparked a monetary revolution which makes Hayek's vision a reality. The proliferation of digital currencies, which could be more convenient, resilient, and useful, are challenging the existing value exchange process based on fiat currency. In turn, this could stimulate central bank money to be more user-friendly in the digital world.

### Taxonomy of Digital Money

Digital currencies can be classified into various categories subject to an evolving typology. This part will briefly survey some existing taxonomies before presenting a simplified politico-economic model that focuses on issuer types to capture their competitive dynamics.

#### *Literature review*

According to Bech and Garratt (2017) the "money flower" reflects what appears to be emerging in practice and classifies money according to four properties: issuer (central bank or other), form (electronic or physical), accessibility (universal or limited), and transfer mechanism (centralized or decentralized, i.e. peer-to-peer). Adrian and Mancini-Griffoli (2019) further refine the "money flower" into a complementary, branch-like framework called the "money tree". It highlights four attributes of means of payment: type (a claim or an object), value (fixed or variable value redemption), backstop (government or private), and technology (centralized or decentralized). Finally, Bullmann, Klemm and Pinna (2019) introduce the "crypto cube", figure 3, which identifies crypto-assets according to three criteria: the existence or absence of an issuer, the decentralization or centralization of responsibilities, and what underpins the value of a crypto-asset and its stability.

[2] Cryptocurrencies designed to minimize the volatility of the price of the **stablecoin**, relative to some "stable" asset or basket of assets. A **stablecoin** can be pegged to a cryptocurrency, fiat money, or to exchange-traded commodities (such as precious metals or industrial metals).

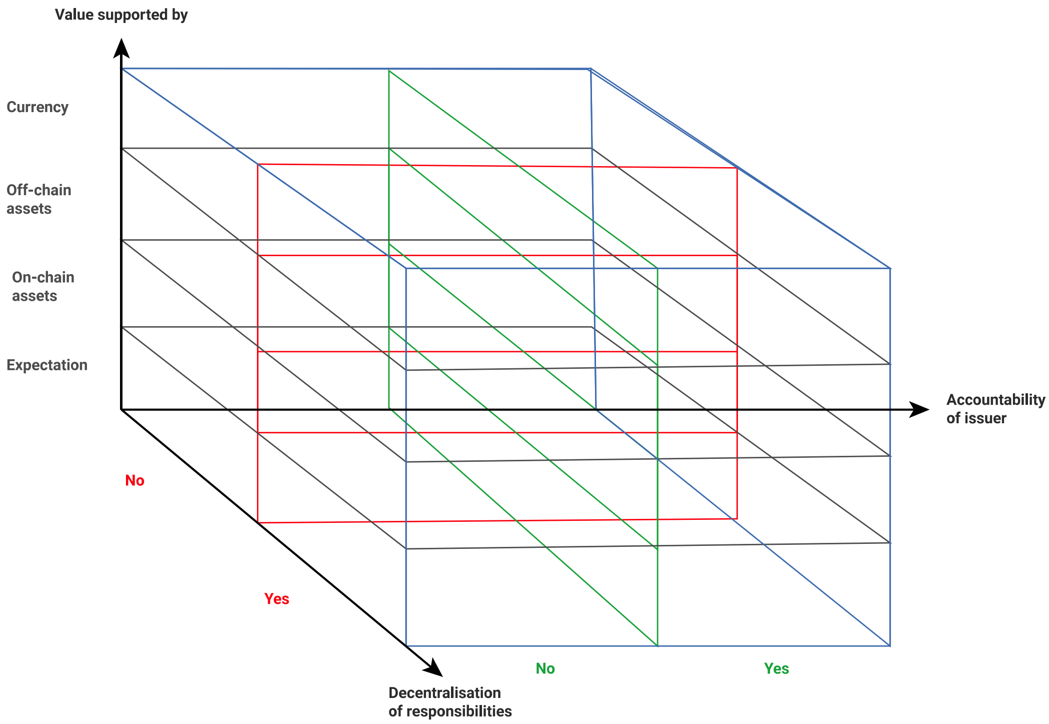


*Figure 3: The Crypto Cube (Bullmann, Klemm & Pinna, 2019)*

*A politico-economic model*

Complex technologies such as blockchain contain a "margin of manoeuvre", a contested terrain in which alternative politico-economic visions compete with each other (Manski & Manski 2018). In the case of blockchain technology, its generative nature allows a range of third parties to innovate upon it. This opens up the possibility for new actors who wish to use the technology to subvert the existing sovereign order. In monetary arrangements, this is a revolutionary era in which currencies are continually being re-invented by a diverse group of creators, ranging from the cypherpunk communities, startups, crypto companies, social media networks, financial institutions, to governments. Furthermore, competition and alliances are formed between them in surprisingly new ways.

The taxonomies of digital money surveyed above have two attributes in common: the nature of the issuer (public, government or private) and technology (decentralized or centralized). By adopting a simplified framework based on these attributes alone, the politico-economic interactions between the different groups of actors can be appropriately captured. Accordingly, firstly we establish the dichotomy that comprehensively cuts the digital currency landscape: trustlessness vs trustedness. The former recognizes the libertarian and decentralized origin of cryptocurrencies. The latter considers the three main groups of stablecoin issuers, corporations, and governments.

**Ideologies, business models, and sovereignties**

Based on the simplified taxonomy, this section successively outlines four sets of digital currency players, from decentralized communities, first-generation stablecoin issuers, corporations, to central banks. Together they span the full spectrum of social coordination, from the most decentralized to the most centralized.

*Trustless*

Bitcoin represents the first example of blockchain technology which enables trustless direct exchange among network participants. Often described as having a libertarian tendency, it challenges existing institutions by removing the need for centralized intermediaries. As a form of money, Bitcoin's key innovation is to simulate a bearer instrument digitally on a register that is global, decentralized, transparent, and open. As a consequence, Bitcoin exhibits some unique characteristics, including an emphasis on individual sovereignty, resistance to censorship, and a monetary policy that is politically neutral moving towards Hayek's view (Hayek, 1976).

More importantly, the blockchain and public consensus mechanism that Bitcoin inspired ushers in an era of decentralized computing. It is the idea that a computer application can be run simultaneously on many computers around the world rather than just one central server, in a way that trusting the honesty or integrity of any one particular computer can be avoided (Van Valkenburgh, 2018). From a politico-economic perspective, this enables cryptosecession, the creation of new decentralized governance structures through blockchain applications which allows individuals and entrepreneurs to exit existing institutional hierarchies. This forms an entirely new cryptoeconomy, a non-territorial collection of governance structures where interaction and exchange are governed through blockchain technology, rather than governments and firms (Allen, 2019). Bitcoin relies on a system of financial incentives through the proof-of-work algorithm to verify and record transactions. Later projects make use of tokens to incentivize both economic and governance participation: economic participation in terms of an accounting system that tracks and rewards contributions, and governance participation through voting, decision-making, and the ability to propose initiatives (Swan, 2019).

*Trusted*

*Stablecoin issuers*

Stablecoins were introduced to bring stability to the volatile market of cryptocurrencies with reference to assets such as fiat currencies or commodities. In general, three price stabilization mechanisms are recognized: off-chain collateralized, on-chain collateralized[3], and non-collateralized (algorithmic) (PwC & Loopring, 2019). While these designs are more innovative and decentralized, with no requirements to trust a single counterparty, they are yet to succeed in any material fashion. The focus is on off-chain collateralized stablecoins, which involve a centralized issuer holding an off-chain, real-world asset. Stability is underpinned by the fact that the stablecoin can always be redeemed for the corresponding off-chain asset. Fiat-collateralized stablecoins are the most simple to understand, and is where the most substantial activity is observed. The top three stablecoins by market value, namely Tether, USD Coin, and Paxos Standard, are all pegged to the US dollar. Tether accounted for 69% of the $3 billion stablecoin market in 2019. It is also the second most actively traded cryptocurrency at 75% of Bitcoin daily trading volume (Blockchain, 2019).

Trading represents the largest use case of stablecoins. They allow exchanges and traders to price pairs in fiat terms, hedge exposure and seek short term stores of value during market downturns - without bank connectivity and the associated latency of the current financial markets processes. Stablecoins could also potentially underpin the next generation of faster and cheaper payment rails, and act as a store of value for citizens with a hyperinflationary national currency (PwC & Loopring, 2019).

[3] The latter two respectively rely on the overcollateralization of on-chain assets and algorithmically adjusting the coin supply to offset changes in coin demand to achieve price stability

Stablecoins generally share similar business models and typically profit in two ways. Firstly, stablecoin issuers charge fees to issue and redeem stablecoins, generating revenue based on fluctuations in demand. Secondly, issuers invest collateral in the short term and liquid securities (such as treasuries and money market funds) to generate yield (Binance Research, 2019a).

An emerging business model is decentralized apps (dApps) powered by programmable stablecoins, of which finance is a major area. This is in part due to blockchain technology's potential in establishing new financial services infrastructure and processes. Some of the transformative characteristics of blockchain include immutable and distributed record-keeping, reduced information asymmetry, and autonomous execution capabilities, which collectively eliminate the need for a common/central enforcer of trust in the ecosystem (World Economic Forum, 2016). By way of their blockchain-native and programmable nature, stablecoins will be a crucial part of this new financial services infrastructure to govern value exchange between users and providers directly without the involvement of intermediaries and create complex financial instruments. With the emergence of stablecoins, there are decentralized exchanges that enable traders to book capital gains or convert to cash through P2P mechanisms without government involvement. Other examples include debt, insurance, staking, prediction, and gambling platforms that are powered by price-stable units. The dApp economy is still in its nascent stage and without any widely used application. The European Central Bank has identified more than 2,000 dApps, which are being used by over 100,000 active users on a monthly basis (Bullmann, Klemm & Pinna, 2019). Outlier Ventures estimates that the decentralized finance ecosystem is worth around $1 billion in its entirety (Outlier Ventures, 2019).

*Corporations*

In contrast to stablecoin projects that are launched by dedicated companies and foundations or cryptocurrency exchanges, an emerging class of stablecoins is being created by traditional financial institutions and bigtechs (Frost et al, 2019). For these new issuers, stablecoins present an opportunity for them further to develop their robust ecosystem of users and services. Traditional commercial banks can rely on their large number of stable customer relationships and suite of financial services. For bigtechs, apart from their established digital networks and large user base, they have competitive advantages in proprietary customer data from their non-financial services and access to advanced technologies to process big data (Financial Stability Board, 2019). At work here are two-way network effects, which compresses time-to-market of corporate stablecoins deployed on the already-existing digital networks of banks and bigtechs without having to bootstrap their own networks.

Many companies and financial institutions are evaluating the issuance of their own stablecoins. Industry verticals that are particularly active include finance, social media, and retail. Stablecoin projects that are already released by banks include J.P. Morgan's JPM Coin and Mizuho's J-Coin. In social media, disclosed examples include Facebook's Libra, Japanese Internet giant GMO's GMO Yen, and Russian social media network VKontakte's VK Coin. In retail, Walmart has reportedly filed a patent for a stablecoin of its own (McIntosh, 2019).

Corporate stablecoins mark a transition from an interest-collecting business model to one that improves internal business processes or even underpins entirely new digital ecosystems. The former is best illustrated by JPM Coin, a pioneering blockchain settlement product primarily used for settlement and value transfer use cases. Launched by J.P. Morgan in February 2019, it initially targets efficiency gains and risk reduction in clearing and settlement functions, as well as cost reductions across back-office functions for institutional clients. While JPM Coin and similar offerings by other banks are unlikely to displace publicly-traded stablecoins given their closed ecosystems built on private blockchains, it is possible for them to disrupt the entire stablecoin industry as they expand their use cases through the extensive networks and asset base of financial institutions (Binance Research, 2019a).

Libra is a canonical example of data giants venturing into stablecoins to underpin digital ecosystems. Announced by Facebook in June 2019, it is a stablecoin backed by stable financial assets which will be incorporated into the Facebook ecosystem built around Messenger, WhatsApp, and Facebook. With billions of existing users, Libra will have a global footprint from day one. With a low-volatility digital currency and a smart contract platform, it creates new opportunities for financial services innovation. In the short term, it may empower billions of unbanked people through financial inclusion and cost savings in prominent use cases such as remittances and government welfare payments (Zetzsche, Buckley & Arner, 2019). In the medium to long term, it has the potential to become a platform upon which new financial services providers can build innovative decentralized applications on the Libra network (Binance Research, 2019b).

*Central Banks*

In the past century, competition for pre-eminence in the international monetary system has been confined to sovereign currencies. With the advent of digitization and blockchain technology, the proliferation of decentralized and private forms of money has accentuated competition. Emerging literature has started to investigate the implications of competing currencies. It is found that a global digital currency could lead to a "crypto-enforced monetary policy synchronization", restricting monetary authorities from pursuing their own monetary policy or setting exchange rates (Benigno, Schilling & Uhlig, 2019). As their monetary sovereignty is being challenged, central banks have been deliberating on a digital upgrade of fiat currencies that could allow them to compete more effectively. One possibility is Central Bank Digital Currency (CBDC), a new form of money issued digitally by the central bank and intended to serve as legal tender. By the Asian Development Banks's (ADB) count, there are 28 existing and announced projects by major central banks on CBDC (Asian Development Bank, 2019).

According to a survey by the International Monetary Fund (IMF), central banks perceive a range of benefits and opportunities brought by CBDC. Foremost is countering the growth of private forms of money to maintain financial integrity, financial stability, and monetary policy effectiveness. There are also opportunities for cash displacement in advanced economies and financial inclusion in emerging markets. Other benefits include broader access to central bank money, cost efficiency, better tracking of economic activities, and modernization of payment systems (Mancini-Griffoli et al., 2018). As private stablecoin initiatives proliferate, it is only a matter of time before central banks move forward with their digital equivalents. ING chief economist Mark Cliffemight predicts that CBDCs will be deployed in just two to three years, as the imminent launch of Facebook-led Libra in 2020 is adding a sense of urgency amongst the policy community (Palmer, 2019).

**Possible futures**

The public and private actors outlined in the previous section do not exist in separate vacuums, but rather continuously interact with each other. Using insights from Schumpeterian evolutionary economics, either competition or partnership could emerge from the symbiotic relationships among players. This section discusses three successive development scenarios in the short, medium, and long term, namely partnership between public and private actors, competition between sovereigns, and transition from trusted to trustless alternatives.

*Public-private partnership*

The massive scale of stablecoins rolled out by digital giants, and financial institutions will accelerate the need for a prompt regulatory response. In this sense, Facebook's Libra is a market disrupter, as demonstrated by the high level of regulatory attention it has received. In the realm of fintech, it is an example of innovation that will move from "too small to care" (like niche stablecoin issuers) to "too big to fail" in a very short time (Arner, Barberis & Buckley, 2016). On the other hand, for countries that decide to introduce a CBDC, they will be faced with unprecedented operational and reputational risks as central banks lack experience in managing consumer-facing infrastructure. By adopting a public-private partnership approach, however, central banks can rely on the distribution power of private actors and seek to have scale and reach immediately.

Such an approach is formalized by the IMF as a "synthetic CBDC", or simply "sCBDC" (Adrian & Mancini-Griffoli, 2019). It is a model in which the central bank creates tokens while outsourcing several steps to the private sector, including technology choices, interface designs, customer management, transaction monitoring, AML/CFT, and regulatory compliance. The central bank merely remains responsible for offering settlement services between trust accounts. It is a far cheaper and less risky model compared with a full-fledged version of a CBDC in which the central bank creates tokens and offers accounts directly to the public. It also preserves the comparative advantage of the private sector to innovate and interact with customers, and of the central bank to provide trust and efficiency.

In fact, China's soon-to-be-launched CBDC seems to be following this approach. The People's Bank of China (PBOC) acknowledges at the outset that, given China's vast geographic and economic diversity, the CBDC is a complex project that cannot be managed by the PBOC alone. China's CBDC will employ a two-tier operational structure, with the PBOC at the upper level and commercial banks at the second level. Banks are designated as fiat-to-digital currency conversion agents. More specifically, the CBDC is issued digitally by the PBOC as legal tender, and 100% backed by the reserves commercial banks pay to the PBOC. This dual delivery system can leverage the existing resources and distribution channels of commercial banks, and smoothly scale the acceptance of the digital currency. Furthermore, by retaining the intermediary role of commercial banks, competition between the CBDC and bank deposits can be avoided, hence maintaining financial stability (Zhao, 2019). Elsewhere, major cryptocurrency exchange Binance is also promoting a public-private partnership approach. In August 2019, it announced Project Venus, an open blockchain project designed to foster new alliances and partnerships with governments, corporations, technology companies, and other cryptocurrency companies and projects to create new digital currencies (Binance, 2019).

*Geopolitical competition*

In the medium term, early examples of sCBDC will drive other central banks to reactively follow suit and launch their versions in partnership with private actors. As they are faster, cheaper, and easier to use, these sCBDCs are a better representation of fiat currencies and the projection of geopolitical influence. The fast-tracking of China's CBDC in response to Facebook's Libra is the most high-profile example of the looming "war of currencies" (Casey, 2019) in which countries seek to strengthen their sovereign currencies. Major nations like China will attempt to gain a more significant role in international trade through their digital currencies. Per Gresham's Law in reverse, good money pushes out bad. This will be especially challenging for nations that are smaller or with weaker institutional environments, as a substantial shift from local currencies to more superior sCBDCs will mean a loss of control over monetary policy (Zetzsche, Buckley & Arner, 2019).

To counter this, smaller countries could form alliances, or leverage existing ones like the European Union or the Association of Southeast Asian Nations, and launch regionally hegemonic sCBDCs. For example, France and Germany have called for the launch of a European-wide public digital currency to regain monetary sovereignty in the face of Facebook's Libra (Guarascio, 2019). On the other hand, because digital networks today such as Amazon, Facebook, Alipay, and Tencent remain dominant only regionally and are not truly global, any digital currencies that central banks deploy in partnership with these networks would be confined to geographical blocks. One conceivable outcome is the emergence of digital regional currency areas, which entails the risks of geopolitical competition and fragmentation of the international monetary system (Cœuré, 2019).

It is also possible that global central banks could cooperate to reap the benefits of recent technological advances if we are to avoid regionalization and fragmentation. For example, Bank of England Governor Mark Carney has called for a new digital Synthetic Hegemonic Currency, which is composed of a basket of CBDCs, to dampen the domineering influence of the US dollar on global trade and finance and support better policy outcomes (Carney, 2019). Arguably, however, the appetite for global economic cooperation is low today.

*A decentralised future*

In the long run, the proliferation of new forms of money - including stablecoins, and corporate and central bank digital currencies - may merely act as a bridge and educational tool for the mainstream public to transition from legacy systems into a new tokenised economy (PwC & Loopring, 2019). Crypto-enthusiasts may argue that digital currencies issued by centralized entities are not indeed cryptocurrencies for the censorship concessions made. Nevertheless, they provide a compliant and price-stable steppingstone which drives broader familiarity with blockchain technology and flatten the learning curve for everyday participants. Ironically, more collaborations between central banks and private stablecoin providers may provide a massive boost to the credibility, legitimization, and adoption of cryptocurrencies and blockchain technology.

One central tenet of decentralized cryptocurrencies like Bitcoin is their independent monetary policies free from the influence of political considerations. Many observers have associated their adoption with political uncertainty, such as the escalating US-China trade war and the currency crises in Argentina or Venezuela. Importantly, millennials, the generation born between 1981 and 1996, are expected to provide strong tailwinds for the adoption of Bitcoin. With the largest demographic in the world and disposable income soon to supersede all other generations, their mistrust of governments and banks makes them open to cryptocurrencies (Adamant Capital, 2019). To cater to this generation and remain competitive, it is possible that centralized digital currency issuers will provide new on-ramping options and exchange pairs with decentralized cryptocurrencies, leading to their real mass adoption.

## Conclusion

It has to be caveated that the three scenarios outlined above are not mutually exclusive, nor will they follow a straightforward temporal order. Due to the preferences and tradeoffs of countries, corporations, and consumers, there will be detours, and it is possible that the scenarios could co-exist. For example, nations may impose restrictions and constraints on foreign digital currencies to bolster their home currencies. Digital currencies launched by central banks and corporations may enjoy a certain degree of popularity due to better guarantee on legitimacy and consumer protection. On the other hand, the backlash over privacy and data monopolies will drive demand for decentralized cryptocurrencies. The only thing we can be sure of is that there will be enlarged currency choice sets for citizens and regulating them will be challenging.

In the final analysis, the world of money is in an unprecedented era of innovation and competition, driven by rapid technological advances and shifting consumer behaviours. This is triggering a rethink of global monetary arrangements. The pace of transformation will only accelerate, as major stablecoin projects such as Facebook's Libra will trigger a range of similar proposals from other bigtechs or financial institutions. This will in turn force one or more major currency central banks to move forward with a CBDC, possibly in partnership with private actors (Zetzsche, Buckley & Arner, 2019). This calls for a regulatory response to create an environment in which private and public digital currencies can thrive alongside and effectively complement each other. It is also an opportunity for central banks to improve their sovereign currencies to maintain public trust and stay in the game in a digital and decentralized economy. As former IMF Managing Director Christine Lagarde notes in a speech at the Bank of England, "virtual currencies might just give existing currencies and monetary policy a run for their money. The best response by central bankers is to continue running effective monetary policy while being open to fresh ideas and new demands, as economies evolve." (Lagarde, 2017). In the spirit of Hayek's monetary competition (Hayek, 1976), continued experimentation will drive us closer to a blockchain-based programmable and tokenised economy that is fair and inclusive.

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## Part B: The New IOV Financial Ecosystem

*Hermann Elendner*

The IoV has shifted digitisation from the level of information and communication to now also include digital scarcity. This has allowed for a virtual representation of economic wealth and its easy and efficient transfer. As a consequence, economic institutions and activity have rapidly shifted to near-instantaneous computer networks. The first functions to develop in the IoV, with blockchain technology, were payments and investments, in the form of cryptocurrencies. Business cases quickly proceeded to securitise illiquid assets or usage rights from file storage to real estate.

The close-to-frictionless mode of operation in the IoV is proving superior to traditional marketplaces in terms of transaction costs, operating hours, and ease of access. This has led to a wave of disintermediation also in the realms of innovation financing and private equity: startups are increasingly applying the tokenisation of their product as a means to both raise funds as well as target and influence their customer markets. Recently, the developments have bifurcated into centralised service providers catering to blockchain ecosystems, and an equally strong push to build as much financial infrastructure as possible in a fully decentralised manner, true to the fundamental blockchain idea, under the label of Decentralised Finance (DeFi).

**A tokenised world**

"The tokenisation of everything" has become the theme of a move to represent all "offline assets" by digital tokens, that are transferrable quickly and at low cost. Just as the internet increased the efficiency of communication in existing enterprises, it also paved the way for numerous novel business models. DLT has also introduced transformational new business models: peer-to-peer structures with democratising effects that are uprooting monopolies or strong oligopolies from money (seignorage) to investment, from trading to fundraising, from logistics to supply-chain management. The IOV is also giving rise to entirely new forms of economic organisation, in particular Decentralised Autonomous Organisations (DAOs) (Buterin, 2014), which arise from new possibilities for governance combined with high-level automation. The common share traded publicly on a traditional stock exchange is being eclipsed as a means to structure both cash flows and control rights (Jensen, 1991). Finally, even decisions that still need to be made by humans are indirectly affected by DLT mechanisms. Determining who is to be granted agency, and to what degree, for each decision situation-optimising governance by mutually interdependent human-machine configurations, which has become the most recent highly active field of research and development.

The new IOV business models in finance can thus be categorised into three successive generations of digitisation, which are based on the consensus DLT provides. The first generation, classical blockchain and thus most cryptocurrencies, established decentralised consensus about state. Most prominently, Bitcoin ensures a shared "truth" about how many coins are held by each address. The second generation introduced smart contracts and DAOs through consensus about procedure. Effectively, this began with Ethereum endowing all nodes with a common Turing-complete programming language. This generation allows smart contracts to be combined to create entire virtual organisations devoid of humans. Limitations on foresight that materialised in this generation spurred the third generation, engineering decentralised consensus on agency. Within this third generation, the governance structure is optimised to combine decisions made by computers, by humans, and by committees of any combination of such to run an organisation.

Importantly, the success of DLT has spurred a wave of re-thinking financial business models in general: many had not yet fully taken advantage of digitisation per se. Clearly, efficiency gains should be exploited, and frequently serious innovative pressures have arisen from the disruption of the financial industry's status quo by digitisation alone. However, the fundamental innovation with the IOV has been decentralisation as introduced by the blockchain, now more generally referred to as DLT, due to later non-blockchain-based protocols. In the next sections, new DLT based business models in the financial services world are discussed, broken down into decentralised consensus-based on state and decentralised consensus-based on procedure.

**<u>Decentralised consensus based on state</u>**

The first DLT was Bitcoin, proposed (and shortly after released) by Satoshi Nakamoto (Nakamoto, 2008). While at an immediate level Bitcoin presented the first cryptocurrency, the more abstract perspective is that it introduced a protocol aligning mathematical problems with economic incentives in a way to ensure (provided that the majority of participants remained honest)[4] eventual consensus about the "ownership"[5] of every token it generated. In short, the blockchain achieves two things simultaneously: first, it generates purely virtual units of economic value (by achieving social scalability, (Szabo, 2017), and second it ensures agreement about which unit belongs to whom (in terms of pseudonymous addresses).

At its core, the blockchain provides the functionality of a large look-up table of every token and who is entitled to send it[6] via their electronic signature. The key innovation was not the efficient data structure or low redundancy; the key was to get all participants to agree on the same attributions (despite wanting more tokens themselves). And to maintain this consistency across time despite frequent re-assignments (transfers), the non-synchronicity of computer networks, and prevalent desires to censor, duplicate, or otherwise manipulate transactions.

*<u>Virtual digital tokens</u>*

While it appears more demanding to build a technical system which not only achieves consensus about allocation changes, but also to generate purely virtual tokens with economic value, in fact, the opposite is true. Through reliance on purely virtual tokens, DLT sidesteps the complications of bridging the real/virtual divide. A purely virtual system can content itself with consistency and does not need to address truth. Once the blockchain achieves consensus about who is entitled to control a coin, this is sufficient to effectively establish ownership in the practical sense. A token that should represent some state in the physical world is encumbered by the additional problem that what the computer network may agree to, could well fail to agree with reality.

It turned out that to attribute value to virtual tokens was easier to achieve than attributing accurate virtual representations to real-world phenomena. Scarcity of virtual tokens is a necessary condition;

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[4] For a discussion about whether the majority is required to be honest and altruistic, rationally selfish, or acting in Byzantine manners, see Ford and Böhme (2019).

[5] Ownership is under quotation marks as the technical system ensures no legal position, but rather the technical possibility to "spend" the received balance, i.e., the exclusive capability to send received amounts to following beneficiaries.

[6] This analogy is not precise from a technical point of view, as bitcoins are highly divisible into 108 subunits named satoshis, and the Bitcoin protocol does not store a reference from satoshis to their owner (with the exception of block rewards) but rather a concatenation of transactions, so that "ownership" of an amount means control over a yet-unspent transaction amount; however, this setup achieves functionally the effect of an up-to-date look-up table, and many other cryptocurrencies actually implement data structures corresponding quite closely to such a table.

in combination with an efficient way to transact[7] and an initialisation scheme successful to onboard enough users[8], it becomes sufficient.

*Cryptocurrencies*

The first blockchain business model was a payment system encompassing a monetary system with private seignories. Bitcoin, with its associated mining, quickly became a professional and competitive business with block rewards as a revenue source. As most cryptocurrencies are still based on PoW, and most other coins (e.g., PoS blockchains or DAGs) also provide incentives for verifiers, the business extends to the majority of coins.

Despite the ongoing debate about whether cryptocurrencies are money (Yermack, 2015), innovations in DLT to establish payment systems are a strong business case. This includes the multitude of payment solutions working at bridging the cryptocurrency/fiat currency divide.

Due to the quick multiplication of coins available, another financial business case that evolved from the early days of blockchain where crypto -exchanges and marketplaces for trading cryptocurrencies against each other or fiat money.

The large volatility of most cryptocurrencies' prices has led to a demand for so-called stablecoins, a young business case to provide low-volatility tokens, useful as units of account. However, still, no agreement exists about what exactly to stabilise, or how.

Strong activity in crypto exchanges led to what came about as auxiliary services and quickly developed into new business models: borrowing and lending, as well as margin trading.

In parallel, due to large and growing numbers of crypto tokens and their return characteristics (Elendner et al., 2018), strong growth is expected to continue for business models of crypto-asset management, portfolio management including traditional and crypto assets, and other investment-management activities.

Particularly noteworthy is the strong emphasis on data-driven approaches: advanced analytics, in particular approaches, based on artificial intelligence or machine learning, as well as on sentiment analysis (and thus frequently natural-language processing) play an important role in portfolio management with crypto assets.

*Utility tokens*

In contrast to cryptocurrencies, characterised as virtual tokens without intrinsic function other than transferability, utility tokens encode a claim to a service.

The increasing issuance of utility tokens has coincided with the growth of blockchain-based business models to generate demand for the tokens. Commonly they are sold early in a project's life cycle as a means of raising financing, possibly but not necessarily in an ICO. A classic example is filecoin (filecoin.io), a token to pay for storage on the InterPlanetary File System (IPFS), a blockchain-based network saving data in a distributed file system. While filecoins will trade on exchanges like

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[7] Blockchain-based cryptocurrencies are efficient to transact in certain circumstances (e.g., sending large values across continents and state and legal boundaries within minutes to a little-known recipient) and not so efficient in other circumstances (e.g., as fast as possible transfers, large numbers of transactions per second). The point for the argument here is that some useful use cases exist, so that the DLT generates some value as a transaction system.

[8] Various schemes (co-)exist, with time trends in their prevalence. After the initial approach of no initial balances with decentralised mining, also airdrops, proofs of burn, the distribution of pre-mined coins, ICOs, or forks have been successfully employed at various times.

cryptocurrencies, the token is not meant to function as money or investment (although it may appreciate or depreciate) – it is designed to resemble a voucher for services provided.

This is the critical aspect of utility tokens: they are a critical fully decentralised way to provide resources for decentralised applications.

An important aspect of utility tokens is that as far as US regulation is concerned, a strong utility aspect should not render the token a security under the Howey test – and thus wide-ranging securities regulation is not applicable.

*Security tokens*

The third class of static crypto tokens are security tokens. As the name suggests, they resemble shares in a joint-stock company. As the regulatory uncertainty about their status has by now been resolved in most developed jurisdictions, security tokens are now controlled under securities law. This means that a serious degree of effort and cost is required to issue them in a legally compliant way and as such their popularity has decreased significantly.

The one remaining business case where security tokens have been used is for fundraising if a utility token is deemed inappropriate or insufficient and the expected proceeds are high enough to warrant the lengthy and expensive process, which may still be much cheaper than an IPO. An advantage is the possibility to structure cash-flow rights in any way. However, for complex structures where not only cash-flow or static voting rights should be settled, governance tokens provide possibilities exceeding those of securities in financial markets.

*<u>Digital representations of offline assets</u>*

As detailed earlier, "putting offline assets on the blockchain" faces a tension. On the one hand, representing offline assets on a blockchain requires a bridge between the real/digital divide, which is hard without a trusted third party. On the other hand, registries are an ideal use case for DLT due to their immutability.

*Tokenisation with a legal basis*

If an anchor outside the blockchain is embraced, the tokenisation is supported by a legal or contractual basis. A prime example is a land registry[9] introducing near-instantaneous, counterparty-risk-free, notary-free, and cheap transactions. Other property registers would work in the same way. Prominent business cases include trading and settling traditional financial assets on DLT, as well as supply-chain management. A decentralised system can work in industry settings where legal or competitive reasons prevent one player's control over the supply chain.

*Tokenisation based on incentive structures*

The alternative to authority outside the DLT lies in incentive structures that ensure desired behaviour. Examples include identity and reputation systems, where participants cross-check each other, or verification systems, where they establish validity or attention tokens. Since most of these use cases are non-financial, they fall outside the present focus.

**<u>Decentralised consensus based on procedure</u>**

While first-generation blockchains effectively provided a shared ledger of key/value pairs, a natural next step was to extend consensus to include procedural stipulations. Ethereum (Buterin, 2014) was

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[9] An example of a start-up aiming to put real estate on a blockchain is brickblock.io.

first to offer, with its Solidity, a Turing-complete programming language for code to be executed on the Ethereum Virtual Machine (EVM) by all the nodes in the network. Effectively, this provides a way to write programmes which then run on other people's computers without leaving to their discretion the integrity of execution. The distributed nature of the network ensures multiple independent verifications of the calculation, and the consensus algorithm ensures no single entity controls what is considered the output of the execution. Consensus based on procedure ultimately introduces "an un-ownable computer," programmable and usable by anyone. Many business models have sprung from this most fundamentally, in competition as an alternative DLT solution, but far more commonly, in developing smart contracts and decentralised applications running on a major established platform like Ethereum, Hyperledger, NEO, or NEM.

*Smart contracts*

While the idea of smart contracts (Szabo, 1997) pre-dates the blockchain by at least a decade[10], Ethereum kickstarted the spread of smart contracts.

In a sense, "smart contract" is a misnomer, as arguably they are neither smart nor contracts. They do not constitute a contract in the legal sense, and they cannot react sensibly to unforeseen circumstances – so are just as smart as any computer programme, or rather its programmers. The key distinction is that the code's execution is delegated to the blockchain, and therefore independent of any single entity. In this way, smart contracts can incorporate information or actions available only in the future, while remaining censorship-resistant and manipulation-proof.

The Ethereum whitepaper (Buterin, 2014) classifies smart contracts into three categories: financial applications, semi-financial applications and non-financial applications.

Alternative meaningful classifications could well be proposed. For instance, a critical distinction occurs along the line delineating smart contracts that operate without a need for off-chain data from those meant to react to information outside the blockchain. While technically such information must be brought on-chain, it raises a host of problems commonly referred to as the oracle problem – how to get an on-chain data representation of a state of nature that ideally is as trustless as the blockchain and truthful insofar as to describe the true state correctly.

The task to act as an oracle that enters relevant data as a trustworthy, reliable, and timely source onto blockchains has evolved as a business opportunity. In cases when data is generated by or otherwise under the control of a firm, the oracle problem becomes vacuous[11], and a business case arises naturally.

For consistency, the following description of financial business models is structured in line with the Ethereum whitepaper classification (Buterin, 2014).

*Financial applications*

Given that the first and best-known usage of blockchain is cryptocurrency, unsurprisingly business models within the IOV still skew towards financial applications. Moreover, providing decentralised services often (though not necessarily) calls for decentralised payment. Short of physical transfer (cash, gold, precious items) and the Hawala system, which are both unsuited for online business, DLT provides the only decentralised payment systems.

[10] Also, Bitcoin provides a Turing-incomplete script language enabling some smart contracts, for instance, multisignature accounts. See also counterparty.io, implementing a smart-contract protocol for Bitcoin.
[11] Unless the whole business were re-designed to not generate or control proprietary data in the first place.

**Token systems, ERC-20.** Among the most influential smart contracts is ERC-20[12], is used to generate new tokens on the Ethereum blockchain. As all fully decentralised business models in the IoV rely on digital tokens to generate revenue, and at the same time most do not want to rely on a general-purpose cryptocurrency (if only for reasons of volatility alone),( Yermack, 2015), a standard procedure is to generate a dedicated token for the use of the service.

This is one of the most fundamental innovations in business models for the IOV: developing a token economy around custom-made tokens linked to the firm's services or activities[13]. Smart contracts open new possibilities beyond the creation of fungible payment or utility tokens. Customer retention programmes, promotions, data acquisition and user telemetry, complex pricing schemes including discriminative pricing, reward schemes and demand shaping can, for better or worse, all be coordinated and incentivised by appropriate token design. Finally, one of the fastest-growing business models in this area has been consultancy.

**Fund management.** Once economic value is stored in digital tokens rather than traditional account balances, numerous financial-industry functions can be automated via smart contracts. For instance, the trend towards passive fund management amounts to comparatively simple smart contracts for cryptocurrencies. One instance is the C20 token (crypto20.com), resembling an ETF for 20 major cryptocurrencies, yet itself a token that can be acquired and held without middlemen.

In developed financial markets the number of funds exceeds the number of stocks; moreover, smart contracts allow customers to interact close to real-time at low costs (as no human labour is involved on the business side) with increased customisation and close-to-continuous adjustments. It appears a foregone conclusion that there has been to date a small fraction of business cases to be developed in this realm.

**Saving and investment.** In a domain where behavioural finance is documenting a host of human biases in decision-making, an increasing number of business models are built around nudges meant to improve our financial results. Smart contracts effectively endow us with programmable wallets and accounts, possibly aiding in achieving savings goals, investment objectives, and have been used for retirement savings plans.

**Financial instruments and derivatives.** So far, few projects work on matching the rich universe of derivative financial instruments in the IOV, yet this reluctance is fading fast – on both sides.

Online markets for digital derivatives of virtual tokens are implementing a growing number of predictable business models as they emulate traditional instruments.

Simultaneously, traditional financial markets are overcoming their reluctance to business opportunities from the crypto-economy. Starting with bitcoin futures trading on the CBOE in 2017[14], increasingly traditional financial products provide exposure to risks and rewards from the token economy. Recently, the first bitcoin-denominated bond has been placed under UK regulation,[15] three

[12] Technically, ERC-20 is a standard for Ethereum smart contracts; it also provides a template. The Ethereum Request for Comments (ERC) is part of the Ethereum Improvement Proposal (EIP). Since its introduction in 2015, ERC-20 has become the de-facto standard for creating tokens on Ethereum. Due to technical deficiencies, it should be succeeded by ERC-777.

[13] Precursors of the trend were visible in the gaming industry, where revenue streams of developers shifted towards larger fractions from in-game content sales. However, the early (the then-largest bitcoin exchange which failed in 2014, Mt. Gox, started trading cards from an online game and was actually named as a short form for "Magic: The Gathering Online eXchange") and ongoing (wax.io is building a blockchain-based marketplace to exchange video-game assets) links to the gaming industry must not distract from the seriousness of token economics.

[14] In the meantime, the CBOE has ceased trading XBT futures and ceded the market to the CME.

[15] Cf. https://cointelegraph.com/news/worlds-first-zero-fiat-bitcoin-bond-now-available-on-bloomberg-terminal

sovereigns have voiced interest in issuing crypto-denominated government bonds,[16] and a major Spanish bank issued and settled a fiat-denominated bond on a public blockchain. Ethereum tokens represented the bond, and settlement was effected via another ERC-20 token tokenising cash in a custody account.[17]

**Insurance, hedging, and betting.** Subject to the oracle problem but among the most promising use cases are conditional payments. Self-enforcing insurance contracts rely on a trusted information stream about the insured state. This is no different from standard insurance contracts. Insurance against fire or theft, for instance, relies on police documents to process claims, i.e., a trusted third party. The insurance company's business can be automated via smart contracts (Braun et al., 2020). For example, a French insurer is offering smart-contract-based insurance against flight delays or cancellations (fizzy.axa).[18]

Hedging needs can be covered with insurance or financial derivatives, but a use case stands out, namely stablecoins. The recent surge in interest crypto tokens with stable economic value (Pernice et al., 2019) has led to a variety of approaches (most of which rely on oracles) and is driven by the role of stablecoins to bridge between conventional financial and crypto markets. This is the area with the most activity regarding new business models.

Finally, an active field are prediction markets (technically little distinct from betting markets, as long as the uncertainty is not self-generated; see for example augur.net). Their prominent role arises because odds ratios from bets are the closest to a decentralised solution to the oracle problem. Since betting is costly, it prevents cheap talk; and since accuracy is profitable, it tends to incorporate all public information remarkably efficiently.

**Financial inclusion.** Importantly, crypto-only applications have the potential to increase financial inclusion. Put simply, in many developing regions, the prevalence of smartphones exceeds that of bank accounts.

*Semi-financial applications*

This category captures smart contracts with both a financial and a noteworthy non-financial aspect to them. Examples include bounties for the fulfilment of pre-specified tasks, computing services, contracts for work and labour, potentially even employment contracts.

*Non-financial applications*

In a host of use cases, monetary consideration should not play a role. Examples include online voting, censorship-resistant information provision, including identity and reputation systems, etc.

Naturally, non-financial applications often imply a for-profit business model. For example, reputation systems require that reputation cannot be bought. Yet, the operation of a reputation system generates sizable economic value, a part of which can be appropriated by the system operator. Since the focus of this text lies on financial applications, the broad range of such business cases are not considered further.

*DApps*

While smart contracts still rely on the user's interaction with the blockchain, the idea of decentralised applications (DApps) is to build interfaces for blockchain-based use cases that are as convenient as

[16] Cf. https://bitcoinist.com/these-3-countries-tell-imf-they-want-to-issue-bitcoin-bonds/
[17] Cf. https://www.coindesk.com/santander-settles-both-sides-of-a-20-million-bond-trade-on-ethereum
[18] Payments use standard current accounts, but technically operating such business model as crypto-only enterprise would be simpler.

standard “apps,” while at the same time automating the processing to and from a DLT providing the (core) functionality.

Put simply, standard apps use APIs (application programming interfaces) to interact with a (central) database, whereas DApps use smart contracts to interact with the blockchain (or another DLT). While a DApp may interact with any number of smart contracts, the point is that it includes both a front-end and back-end to provide a fully functional piece of software to users. At the same time, at least a part if not all of the programme’s logic and data is on a decentralised network.

Another major characteristic is that DApps are incentivised, usually by cryptographic tokens, to motivate network nodes to process them. Most are also open-source software. Given the explicit remuneration for the execution of the DApp, there is no need to encumber adoption by charging for software licenses; also, the practise increases trustworthiness and reliability.

The main advantage of DApps therefore lies in the fact that nobody (not even the developers or the institution spearheading the DApp) has the power to manipulate the data or processing of a deployed DApp.

While almost any application could be implemented as a DApp[19], the added effort in development and maintenance will in most instances, not be worth it. In use cases where a trusted third party naturally exists or cannot be avoided[20], there is little reason to decentralise the applications. However, in all cases where trust in a distributed network is preferable to the need to trust a powerful central authority, there is a use case for DApps.

Novel financial business cases abound in payment systems, insurance platforms, deposits, lending, and fundraising, and investment management.

*DAOs*

Decentralized autonomous organisations (DAOs) are the logical conclusion of the progression in blockchain applicability. When cryptocurrencies roll out their data (if only an allocation table), smart contracts roll out their computation (in addition to data, and possibly dependent on future information and actions), DApps roll out all the use cases of an application, then DAOs roll out all the procedures of an entire business or organisation.

While clearly, this is not possible for all types of businesses, it constitutes a true paradigm shift in the cases where it is. If an entire organisation is implemented as code that runs on a blockchain, this utilises the unownable computer to generate an “unownable organisation” – not in the sense that there are no beneficiaries, who may well be specified in the smart contracts a DAO employs (resp. consists of), but in the sense that there is no human in control of the operations. Naturally, a DAO will only do what it has been programmed to do (and is hard to update). Still, its decentralised execution on a blockchain makes it impossible to change its procedures without it having provisions to that effect and without manipulating the entire blockchain.

A simple example of a DAO is that of a fund management DAO: a set of smart contracts that allow users to register an account, send crypto tokens to their account for which they are granted a share in the fund (in tokens), have the DAO trade to optimise its portfolio, and allow owners to liquidate their holdings against a payout in cryptocurrency whenever they choose to. This is a simple set of business procedures that can all be implemented via smart contracts and outsourced to a blockchain.

[19] The only true technical restriction applies to systems with poor or inexistent connectivity.

[20] This is why the current trend of governments announcing their intention to put some of their online services on a blockchain is a curious phenomenon, as it is a rare occurrence for government offices to declare themselves non-trustworthy counterparties

Therefore, the DAO becomes an enterprise with no employees and no managers – an organisation without people.

In principle, any business case needing no physical intervention can be fully digitised in a DAO. After all, DAOs do not need to encode all future operations fully. Through their interaction with the blockchain, they can take inputs and decisions into the DAO so it is set up to incorporate such future operations. For instance, The DAO[21] relied on curators to whitelist investment projects.

However, the legal status of DAOs is still unclear under virtually all jurisdictions, as is the question of how to deal with regulatory non-compliance. Such cases can arise even in the best-intentioned implementations, as updates to DAOs are non-trivial. Thus any change in regulation involves the risk of a DAO continuing its operation unaltered when in fact the regulator has ruled that this must not happen.

Of course, provisions for updates can be implemented ahead of time and also wind-down conditions; every responsibly set-up DAO includes such. However, the main purpose of blockchains is to hedge those who prefer an independent solution against central control – insofar as discussions revolve around maximal control of blockchain-based business cases, no matter whether cryptocurrency, smart contracts or DAOs. They are discussions about prohibiting blockchain technology without mentioning so explicitly.

Just as general literacy lost central control over all written records and the printing press lost central control over all printed records, blockchains and in particular DAOs cast doubt on the possibility to achieve perfect central control over all computations and business cases that may be computed virtually. Of course, nothing precludes enforcement in the physical realm, as is still ongoing for written or printed material. However, just as central authority had been hostile to general literacy and the printing press and often antagonised or even fought their progress, the same is visible today. A sense of lack of control (and possibly understanding) is driving significant regulatory efforts to stem the tide of decentralised computing.

The reality, however, shows that in certain circumstances, when agency problems are acute or moral hazard is deemed a severe problem, decentralisation can effectively mitigate those problems, and thus generate economic value. At the same time, flexibility and ease of updating business procedures have proven invaluable in many ways, providing a natural limit to the tendency to decentralise.

Despite regulatory uncertainty (to some degree still prevailing for tokens and smart contracts), it seems safe to predict that free societies will ultimately strike a balance between the need to enforce against illicit activities and the gains from exploiting technological innovation. And DAOs pose in many ways the most consistent form of capitalising on blockchain or DLT.

**Re-insurers.** Re-insurance companies are ideally suited to be run as completely automated enterprises. So far, the biggest roadblock appears to be the crypto/fiat divide. While fiat transactions cannot be embedded in DAOs due to a lack of access to the standard financial system for entities without clear

[21] The DAO. To understand the current reluctance with respect to DAOs, it is crucial to know about the first major DAO, literally called "The DAO." It started in 2016 as the largest crowdfunding success (via token sale) in history, raising more than 100 million worth of euro in ether. It was implemented to be a cryptocurrency venture-capital fund, with shareholders voting on which projects to fund, and subsequent funding and repayment effected in crypto tokens from and to the DAO. Due to a critical security bug in the implementation of the DAO, a third of the funds were drained by an attacker before a month had passed, and the DAO failed spectacularly, causing so much trouble that the Ethereum blockchain miners decided to coordinate a hard fork in order to mitigate the damage. While this emergency measure has arguably worked for Ethereum, the enthusiasm for DAOs was appreciably impaired by the incident. It highlighted the difficulty to avoid bugs in complex pieces of software such as DAOs tend to be, and the particularly risky situation of not being able to update a decentralised application quickly and consistently.

legal responsibilities, there is also not an active insurance market denominated in crypto tokens only. However, the rise of stablecoins may quickly bridge this gap.

**DEX.** Decentralised exchanges are one of the business cases for DAOs receiving most attention currently. The fact that most cryptocurrency trading happens on centralised exchanges, requiring to hold the currencies traded in escrow[22], has led to a push to decentralise the trading itself.

**Decentralised consensus based on agency**

After consensus protocols about a shared state and those about a shared procedure (programme execution), the highest form of decentralised consensus is about agency or governance. While static security tokens can represent voting rights and thus define decision rights to some extent, consensus about agency denotes the significantly broader scope of both possibility and necessity in a decentralised network: both on and off the blockchain.

*Governance on the blockchain*

Three factors elevate governance of a blockchain-based activity or organisation beyond the customary level. The first factor is the possibility of cheap and extensive record-keeping of extensive data sets that cannot be modified later. Such transparency (possibly only within the organisation) can resolve a host of agency problems (Yermack, 2017). Second, the possibility to run internal markets within the organisation, based on crypto tokens. And third and most importantly, programmable tokens (via smart contracts) allow for complex designs of time-varying control rights, with decisions being relegated not only to code but also to human intervention depending on the designed mechanisms. This can allow for improved shareholder (or stakeholder) control while mitigating the amount of involvement required.

With regards to the first factor, business cases ranging from financial-claims trading and settlement to employee compensation, are being implemented. The two further factors are under active research but have not seen many commercial implementations yet.

*Governance of the blockchain*

More attention has gone to off-chain governance, i.e., the governance of the environment around blockchain-based applications. At the latest since the DAO incident and the subsequent Ethereum hard fork, governance structures of the ecosystem of a blockchain have spawned research and debate.

Permissioned blockchains can rely on authority in cases of disputes about how a blockchain protocol should be changed. Permissionless chains have so far fallen back to informal governance by the persuasion of key developers, or to “voting by mining,” a process that may tilt towards too many forks, as the decision to fork implies external effects.

Currently, most businesses active in this field focus on consulting services based on insights from mechanism design. On the other hand, several projects (including tezos.com, decred.org, and dfinity.org) are pursuing the approach that governance of the chain should itself be put into the blockchain protocol. In any case, the importance of meta-governance will most likely push progress in this field.

**Conclusion**

[22] No stock exchange would take ownership of the shares traded there; yet such is the case for almost all cryptocurrency trading until today.

The IOV started when Satoshi Nakamoto solved the decade-old double-spending problem and introduced scarce and transactable, hence valuable, tokens to the internet. What has been quipped as “attaching a banknote to an e-mail” has revolutionised more than just payment systems. DLT allows decentralised systems to reach consensus not only about potentially controversial states of nature, but has evolved to engineer consensus about procedures (with smart contracts and ultimately DAOs) and even agency (enabling governance structures that we have only marginally started to utilise).

Since the first use cases of blockchain technology were financial in nature, and since generating purely digital tokens of economic value is easier than getting real-world data aligned with their representation on a DLT, the business models we see in practice today are still heavily skewed in favour of financial applications. However, despite the conceptual difficulty of DLT and certain inherent inefficiencies limiting its applicability, many more non-financial business cases are visible. Regardless of the current state of the volatile cryptocurrency prices, a factor that does affect the level of public interest, the digitisation of the economy and society at large is progressing with increasing reliance on DLT.

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# Chapter 4: The IoV and Media

*Philippe Rixhon, Soichiro Takagi*

A premium is placed in the media and entertainment sectors for protecting and monetizing intellectual property. Blockchain and DLT with their properties of immutability, smart contracts and decentralisation can provide a possible solution to transforming the sector concerning how content is created, protected and consumed.

DLT's impact can go far beyond this in the context of the IoV. In today's climate where fake news is an issue that can have widespread implications, including the manipulation of democratic elections, the IoV can foster greater trust in the value ascribed to important information and ensure that individuals are not confined to their echo chambers.

In this chapter, how the IoV can transform the media sector is covered. Part A is written by Philippe Rixhon who focuses on copyright and royalties related to media assets. This part begins with an exploration of current and related legislation and then moves on to how the IoV can transform the industry. Importantly there is a discussion on the implementation of and how to seize new opportunities presented through applications of new business models.

Part B is written by Soichiro Takagi, who focuses on how the IoV can transform the broader media sector concerning general content creation. This Part begins with a discussion of the main functions of media in society and how the Internet has changed the sector. It then moves on to challenges faced by the modern media sector and finally, how the IoV could solve these. Importantly this Part discusses issues related to how DLT could be used to improve the provenance of news media and combat fake news.

This chapter was reviewed by Philippe Rixhon.

## Part A: New Media Business Models to emerge from the IoV

*Philippe Rixhon*

For media & entertainment, the IoV will help solve current problems and seize new opportunities.

The fair and efficient distribution of revenues in the digital age is challenging. The creative industries left behind deterministic value chains and operate now on one stochastic value network where rights ownership and availability are uncertain. There are dynamic uncertainties around ownership – who owns what and when, and recent developments such as micro-licensing lead to dynamic uncertainties around availability. Rights ownership and availability will have to be determined in real-time to allow effective licensing and accurate remuneration.

The IoV will be the backbone transfer network that secures contracts as well as digital media properties and supports a wave of to-be-conceived applications enhancing the lives of citizens, businesses and public authorities. The tokenisation of media assets will bring new opportunities to the media & entertainment enterprises such as secondary digital markets, protections of copies, or new modes of fan engagement.

### Background

The Internet is a formidable tool to participate in the cultural life of the community and enjoy the arts, but is not up to speed to protect the moral and material interests resulting from literary or artistic production. Things must and will change.

*Business imperative*

*Diminishing returns – While costs of reproduction and communication to the public are close to zero, the costs of licensing digital assets continue to increase.*

For thousands of years, people have freely conveyed and translated works of others – either verbatim or with mild adaptation – until distribution became mechanical and then digital. Copyright is a child of the printing press; content business models are its grandchildren. The era of mechanical distribution was the *peak of copyright*, the theorised point in time when the maximum rate of return on content was reached, after which it seems to have entered terminal decline. It was the golden age when reproduction and distribution were costly but lasted only until the advent of digitalisation and the world wide web.

If (re)production and distribution are the flow of value from authors to consumers, then content licensing and royalties payment should be the counterflow of remuneration from consumers to authors. In the digital age, rights management is a complicated, imprecise, slow and expensive process. Advanced regulations and sophisticated business models are making it even more complicated, more imprecise, slower and more expensive.

The creative industries are squeezed between the ever-decreasing costs of value flows and the ever-increasing costs of remuneration counterflows – an unsustainable situation. Policymakers are aware of the imbalance and want to fix it, but Web 2.0 can't.

*A stochastic value network – The deployment of new web-based business models led to the emergence of a stochastic value network replacing deterministic value chains.*

The American Music Modernization Act (MMA) (US Congress, n.d.) implies a straight value chain from songwriters and artists to recording companies, copyright owners, new mechanical licensing collectives and digital licensee coordinators, digital music providers, and end-users. The latest European Directive on Copyright (Directive (EU) 2019/790) suggests a similar chain from authors and performers to rightsholders, management organisations, a variety of information society service providers, and several categories of end-users. But the reality is very different. There is a mesh of relationships. Any stakeholder can connect with any other one directly. The end-user of today can be the author of tomorrow and vice versa, and a digital music provider can also be a music producer. This is a value network enabled by interconnected networks using standardised communication protocols – the Internet. The participatory engagement of end-users – also facilitated by the Internet – will only amplify the intricacies of value generation.

The Open Music Initiative of the Berklee College of Music defined the minimum viable interoperability of an Application Programming Interface (API) (Berklee College of Music. n.d) that could typically be used between a recording company and a digital music provider and applied to put the MMA into practice. But so far this API conveys only static and straightforward metadata and does not mirror the complex, dynamic, fluid and transitional nature of the music industry. The MMA will probably remain a temporary and limited solution.

*A wicked problem at the edge – solving complex, dynamic, fluid and transitional intellectual property (IP) challenges in the media & entertainment sector – requires an independent multi-disciplinary approach.*

The aforementioned problem can be characterised by the following six statements:

1. The very notion of copyright is a moving target.
2. The copyright problem can only have a temporary solution.
3. Tinkering with regulations makes matters only better or worse.
4. The copyright issue is a symptom of paradigm shifts.
5. Unrealistic policies have unforeseeable consequences.
6. Solving digital content remuneration is a unique process.

These six statements sound familiar. *Wicked* problems have no definitive formulation or solution. Solutions to *wicked* problems are only better or worse. A *wicked* problem is the symptom of another problem. Solutions to *wicked* problems have unforeseeable consequences. The process of solving a *wicked* problem is unique. Also described by Rittel (1973), wicked problem-solvers work in an area of tension between diverging interests, within which they must make abstraction of their ideals. Copyright is a *wicked* problem; we will not solve it without making abstraction of the partisan interests of opposing lobby groups.

Since 1999, the world has become increasingly interconnected. In 2009, people interacted and shared ideas much faster, were accessing an abundance of information, joining virtual and global communities and trying out new business models. Now in 2019, society is at the *edge* (Shell, 2016), a state expanding exponentially, scratching problems with higher complexity, moving into unfamiliar social scenes, and addressing issues with a higher purpose. We cannot solve the copyright challenge anymore without considering artistic freedom, consumer privacy, children's security, energy consumption or democratic values. No single profession has all the answers.

*Regulatory imperative*

*Legal framework – After numerous national patches, the century-old international Berne Convention remains the core regulation of media & entertainment trade.*

In 1450, Gutenberg was tinkering around with the printing press. Two and half centuries later, Queen Anne granted Royal Assent to the Copyright Act (Copyright Act 1710). First, the technical disruptions of the printing press and phonograph prompted the businesses of publishing and recording. Then, authors requested the protection of their material and moral interests. What the Statute of Queen Anne did for commercial rights, the Berne Convention (Convention for the Protection of Literary and Artistic Works, 1886) did for moral rights such as author's attribution and work integrity. Policymakers regulate creative industries. Faced with the societal impacts of new distribution technologies, legislators balance citizens' freedoms of access with creators' rights to remuneration. Policy had always followed technology. Until 2016, when the European Commission proposed a directive on copyright that targets technologies, which are at best emerging. The paradigm shifted: now, policy is preceding technology – an uncharted territory (Rixhon, 2019).

Now we do the splits. The moral rights of authors should be exercised according to the legislation of the Member States and the provisions of the Berne Convention, WIPO Copyright Treaty and Performances and Phonograms Treaty. Such moral rights remained outside the scope of the directive 2001/29/EC and are only mentioned in the directive EU/2019/790 to reiterate that they are the prerogative of the Member States. Moral rights do not have to be registered to exist, but copyrights – practically albeit not legally – ought to be registered somewhere to be remunerated.

*Music Modernization Act – The latest US legislation entails a database of works, reports of usage, as well as speedy and appropriate remunerations.*

The Register of Copyright designates two not-for-profit entities, a Music Licensing Collective (MLC) on the side of copyright owners and a Digital Licensee Coordinator on the side of the Digital Music Providers, both monitored by qualified auditors. A Musical Works Database will be operated on one side, and Reports of Usage on the other side. At least the collaboration between two stakeholder groups of one deterministic value chain of one content industry is regulated and will be organised.

Considering the multiple challenges around IP on the stochastic value network, the MMA is a modest but significant contribution. It closes loopholes, streamlines the collection and remittance of royalties, reduces legal uncertainty for digital music providers, and adopts the principles of fair market value. Composers, lyricists, performing artists and record companies should receive fairer remunerations. Streaming companies should benefit from the efficiency of a blanket mechanical license and the security of reduced legal exposure. More importantly, the MMA draws a blueprint of stakeholder collaboration that can be adapted and used at various connections of the value network.

*European directives on copyright – The latest EU directive requires to identify and match works, rights and stakeholders, and to monitor usages and remunerations.*

The directives on copyright contribute to the functioning of the Digital Single Market, provide for a high level of protection for rightsholders, facilitate the up-to-date clearance of rights, and create a framework in which the exploitation of works can take place.

According to the EU directive 2019/790 and its various exceptions, the payment of royalties for content communication to the public would require to –

- identify works, rights and stakeholders (authors, users and everybody in between)
- match works and rights, works and stakeholders, rights and stakeholders
- monitor usages of works and remunerations of rights
- fulfil machine-readable contracts
- protect privacy and respect the Berne Convention

on the complex, dynamic, fluid and transitional value network, and not only for music but also for films, press articles, etc.

The American MLC should launch its operations on 1 January 2021; the European directive should be implemented on 6 June 2021. The American task is challenging but technically feasible; the European directive on copyright in the Digital Single Market is a letter of intent. At the technology level, no feasibility study has been conducted. At the business level, the stakeholder dialogue is still stammering. At the policy level, there is no Digital Single Market yet, but a group of 27 national jurisdictions. If at least the travails of the implementation concluded that a new approach is required to solve the *wicked* problem of copyright at the *edge*, time and effort would not have been wasted.

**The IoV promise to media & entertainment**

To date, the IoV is still a research initiative, a work in progress. People who say it cannot be done should not interrupt those who are doing it. On the other hand, panacea marketers should not distract those who genuinely look for business solutions or opportunities. "The effectiveness and efficiency of innovation are directly related to the quality of the interactions between users and innovators during the whole innovation process" (Rixhon, 2002). Accordingly, the following paragraphs are an attempt to connect users (new media business models) with innovators (emerging IoV).

*Tokenisation of media assets*

*Standardisation – Hierarchical tokens could be an effective and efficient solution to the need for standardised asset identification.*

Everything that can be tokenised will eventually be tokenised – that is the foundation of the IoV. "Tokenisation increases the moneyness of an asset. Moneyness is the degree to which an asset approximates cash and thus is useful as a medium of exchange. An asset that can readily be converted into cash is similar to cash itself because it can be sold with little impact on its value and at low cost" (Tasca, 2019). Tokenisation, by increasing the liquidity of the media and entertainment market, may cause a rise in the velocity of exchanges, and in turn, on the general sector activity.

Because tokens have value and owners, one can deliver nearly any kind of solution against them. The hierarchical business tokens on EY's OpsChain (EY, 2018a) can already represent assets and be used to exchange for sophisticated operational and financial services. Media assets are very complex. Long-form musical films are perfect examples of their hierarchical complexity. Rightsholders will want to license such a film as a whole and each of its tracks individually. A vocalist on the second track might have already agreed on some exclusive usage of her recordings during a specific time window. The songwriter of the penultimate track may want to block the performance of his composition in specific territories. Hierarchical tokens, by mirroring the complex structure of media assets, may help identify them and their subparts at and appropriate level of granularity.

*Protection – The non-duplicability of tokens and their incontrovertible relation with related digital assets could protect intellectual property in the digital sphere.*

There was a time when the words piracy and digital rights management (DRM) were in all the mouths of the industry. Technological protection measures are access control technologies meant to restrict the use of copyrighted works. They tried to control the use, modification, and distribution of copyrighted works such as software and multimedia content, as well as systems within devices that enforce these policies (Office of the Privacy Commissioner of Canada, 2006). This was not a success. First, it went against fair use policies and the right granted to consumers to make a few private copies.

Second, it limited voluntarily the propagation of content *only* because the publishers could not monetise the copies. Then, recognising that DRM were counterproductive, content industries and policymakers introduced levies, a suboptimal blanket tax on the copying systems.

The IoV could change that; indeed, it should not prevent copies, provided that each new copy is automatically monetizable; in this case, it should incentivise copying. Digital watermarks and digital fingerprints are tools to identify contents and trigger their protection, local enrichment, or semi-automated monetisation. The breakthrough for automated monetizable propagation could come from the development of non-fungible tokens as shown by the CryptoKitties game. Non-fungible tokens represent something unique and are thus not interchangeable. They are used to create verifiable digital scarcity, user ownership, and the possibility of asset interoperability across multiple contexts in applications that require unique digital items. They are controlled by the user, instead of the publisher. This lets the assets be traded on third-party marketplaces without permission from the originator. Theoretically, a combination of content-based standard identifiers, non-fungible tokens and fungible sub-tokens could solve the challenge – notwithstanding the scalability question.

*Smart contracts*

*Simplification – The automation of intercompany transactions could rely on templates and simplify the intricacies of current contracting.*

It has been said that the music industry is a lawyers' affair and not an artists' business. There is some truth in this statement, and it does not only apply to the music industry. Most interactions among citizens, commercial or governmental organisations are subject to complicated rules and practices. Contractual effectiveness and efficiency will not come without simplification and trust.

Here, the IoV promise is called smart contracts. They are computer programmes, a bit like Excel macros, intended to facilitate, verify, or enforce the negotiation or performance of an agreement. Smart contracts allow the execution of credible, trackable and irreversible transactions without the involvement of intermediary third parties. They present a few challenges. Irreversibility might be a virtue in some applications, but not necessarily in all of them. That could be solved technically. Macros are formulaic standards that constraint the human propensity for exceptions. One could start by coding Creative Commons or similar standardised licences. They are non-revocable, so immutable macros would be an ideal means for recording the licensing information. When rightsholders would register their works on a register using such a license, that license would be attached to the work for all times (De Filippi et al., 2016).

The biggest challenge is our relationship with the code and the expansion of algorithmic governance. Twenty years ago, Lessig (2000) wrote: "Th[e] regulator is code – the software and hardware that make cyberspace as it is. This code, or architecture, sets the terms on which life in cyberspace is experienced". Two years ago, witnessing the advent of blockchain and machine learning, Hassan and Filippi (2017) distinguished between legal rules, which stipulate what people shall or shall not do and technical rules which determine what people can or cannot do, eliminating the need for intermediary enforcement authorities. We are moving into unfamiliar social scenes.

*Transparency – Machine-readable-and-executable contracts could be fitted with real-time monitoring and comply with the most recent US and EU regulations.*

Society is not ready to accept fully automated contracts – at least not yet. Contracts should be understandable. Can users understand coded macros encapsulated in black boxes? Can we understand coded laws whose rules evolve as information is gradually fed into the system? Most contracts are drafted by trusted people, governed by trusted laws and arbitrated by trusted courts. Can we trust machines?

On the other hand, how can we implement the new European directive efficiently on copyright without machine-readable-and-executable contracts? For the time being, we will rely on hybrid human-machine trust assurance. Just like we are boarding planes, that most of us do not understand, reassured by the trust we grant to airline companies, plane manufacturers and civil aviation authorities because we know that the planes are transparent for them. Just like the music industry is going into the MMA, reassured by the fact that the databases *Musical Works* and *Reports of Usage* must be transparent for the Register of Copyrights (a human organisation), systems engineers and qualified auditors.

Similarly, the smart contracts managing licensing agreements and royalties payments will be specified, coded, monitored and audited by teams including trusted lawyers and engineers. These specifications, coding, real-time monitoring and audits will be supported by computers, as it is done in accounting.

<u>*Data architectures*</u>

*Distribution – Previous attempts to centralise identification and metadata of media assets have failed, keeping them distributed could succeed.*

The Global Repertoire Database (GRD) aimed at creating a central database to identify the owners, beneficiaries and administrators of lyrical and musical copyrights, enabling licensees to find who controls the musical works they want to use, and facilitating efficient distribution of royalties (Cooke, 2014). It failed for various reasons. *One* global central database means a single *one* in the world. At first glance, it seems appropriate for *one* world wide web, but utterly utopian as *one* world government or monopoly would be. Other weaknesses included the deficient mirroring of the reality of the music industry, the necessity to handle *clean* data, or the lack of a performing dispute resolution mechanism.

One or many? As soon as one discards the concept of a single database, one should also abandon the idea of a few databanks and focus on interlinking a multitude of data repositories. It would come closer to the reality of human relationships and the nature of the Internet. It would also form a grid that is much more secure and resilient. Public domain or private property? Data are private assets that should be managed, controlled and protected by their owners. Therefore, it seems that a global repertoire ought to be based on a networked architecture of a multitude of private and proprietary data repositories.

The GRD failure was necessary to approach a solution. Lessons have been learned and applied. The Cube copyright platform developed by ICE Services in collaboration with Stage (ICE Services. n.d) and the URights solution developed by SACEM in collaboration with IBM (URights, n.d.) are – albeit through different ways – addressing the weaknesses mentioned hereabove.

*Governance – Notwithstanding the remote possibility of trusted self-regulating systems, governance should remain a computer-aided human task for the foreseeable future.*

Bill Rosenblatt, a globally recognised authority on technology issues on intellectual property in the digital age, wrote recently: “The MLC […] is required to maintain a publicly accessible database of [mechanical rights] information and to accept data submissions in order to improve accuracy and currency. For rights databases, trust and governance are as important as efficiency; and blockchain technology has the potential to improve all of these areas if it can scale” (Rosenblatt, 2019).

The developers are getting there. They may face the *blockchain trilemma*, "a term coined by Ethereum founder Vitalik Buterin that addresses the problem of how to develop a blockchain technology that offers scalability, decentralisation and security, without compromising either one" (Ometoruwa, 2018). Attempts include Plasma that can perform many complex operations by partially running them on a second layer on top of the consensus layer (Plasma, n.d.), or Hashgraphs based on directed acyclic graphs (Hedera Hashgraph, n.d.). Unproven technologies so far, but promising research. Developers compete to reach mainstream adoption. Watch this space.

The MLC is an experiment at computer-aided governance, bringing together recording companies, digital music providers, government, music publishers and songwriters' associations. It must be re-designated every five years. The technical solution will need to be re-designed too if its operator wants to leverage DLT of the latest generation to improve trust in and governance of the rights and royalties system.

*Integration – The full benefit of smart contracts models would depend on their integration with regulatory compliance, tax and audit, and back-office infrastructure.*

Typical issues faced by the media & entertainment industry include manual intercompany invoicing and payment procedures, the lack of materiality thresholds for intercompany allocations and journal entries, inconsistent global intercompany processes due to fragmented ownership, manual Excel and Word (yes!) modelling and calculations, and foreign currency exchange considerations. Using smart contract functionality, an organisation can establish automated intercompany transaction processes. These contracts can have pre-developed processes, transaction thresholds and use "oracles" (e.g. Reuters to inform exchange rates) to reduce manual calculations (EY, 2018a).

DLT will do for networks of enterprises and business ecosystems what ERP did for the single company. They will integrate information and process within and across enterprise boundaries. Using tokens and contracts will be the standard way in which companies transact with each other. However, that will require integrated solutions designed to solve multiple business problems with a solution based on a single distributed database, ensure that data is stored consistently and only once, support connections between processes and facilitate reporting across these processes. It will also require that DLT-based solutions shift from a separate parallel system toward integration with users' back offices and existing laws and regulations to assure seamless business processes, convertibility and audit controls.

**Solving problems**

*What it will take*

*Distributed ledger technologies – To allow the permanent, immediate and transparent booking of licensing transactions in decentralised databases.*

Distributed ledgers will allow media and entertainment enterprises to take advantage of single immutable records distributed across all nodes of a trusted rights network. Electronic markets for media assets will eliminate imbalanced transactions and discrepancies between different back-office systems, report accurately and timely, and improve compliance. The question is not if, but when.

Five developments will be necessary to transform DLT into a standard tool for enterprise interactions. Tokenisation, integration and a solution to the blockchain trilemma have been mentioned. We also need a shift from private blockchains used by corporations to public blockchains used by everybody, whereby the integration of both types could be the better approach. Private blockchains protect the privacy and security of their data. Participation requires an invitation, which itself is validated by a set of rules. Such blockchains are known as *permissioned* blockchains and preferred for B2B transactions. Public blockchains are open networks that allow anyone to participate. These *permissionless* blockchains depend upon the number of users for their success, hence, encourage participation through incentives. Today, they seem indispensable for B2C transactions. Furthermore, we need a transition from cryptocurrencies to fiat-backed *stablecoins* although, again, the integration of both types of money could be the better method, just like the incentivising compatibility of loyalty points and government-backed currencies.

*Other necessary established or emerging technologies – To translate real-life contracts into smart contracts and allow intelligent agents to recognize IP items and environments.*

In the content industries, we love creating assets but dislike managing their metadata. We distinguish between rights data (identifiers, usages, rights, licenses and royalties), catalogue data (necessary to find an asset and for an asset to be found) and content data (enabling the enrichment of user experiences). Metadata in the media & entertainment industry are not yet ready for automated licensing. The use of identification standards is sporadic. Metadata structures differ significantly, are incomplete and contain errors. The poor quality of rights and catalogue metadata, and a century of failed attempts to standardise them, impose the development of intelligent metadata ingestors. These ingestors will rely on machine-trained pattern recognition and rule-based algorithms to digest non-standardised, incomplete and erroneous metadata and transform them in tokenised data subsets tradable through smart contracts.

We are the stewards of extraordinary catalogues but also of unmanageable numbers of agreements. They need to be translated into smart contracts. Here again, we will need machine learning to support lawyers and engineers in their coding efforts.

We will also need digital object identifiers – tags or watermarks added to the media assets or digital fingerprints or content-based block hashes – to allow intelligent agents to recognize IP items and their contexts and maximise the chance of these agents to trigger or fulfil machine-executable agreements successfully. Finally, we will need a lot of computer processing, storage, high-performance networks, and as little electrical power as possible to manage in near real-time complex and dynamic rights associated with billions of daily transactions.

<u>*Where we are*</u>

*Are we at Kitty Hawk with the Wright brothers (1903) or in Dover with Louis Blériot (1909)?*

Development trajectories are for engineers what hype cycles are for marketeers. Propelling planes with steam engines had been attempted, but powerplants with high enough power-to-weight ratios were too difficult to build and abandoned. Combustion engines did the trick, and humans could finally fly in the directions they wanted. Then, came jet engines, a kind of second-generation powerplant. Finally, we connected airports with railway stations and highway interchanges and got a new worldwide transport grid. When it comes to the IoV and media & entertainment, we may be approaching Dover. For capacity, we will have to build Airbus 380s or Mriyas, for speed Concordes.

Imogen Heap "didn't expect to be able to develop a thing [… but thought if she] could just share an idea maybe someone would make something but, in the end, nobody was doing this thing" (Bitcoin Exchange Guide News Team, 2018). Excited by the potential of issuing music on a blockchain, she released the song *Tiny Human* on Ethereum's public blockchain in October 2015. Heap found out that decentralised technology could be leveraged as <u>part</u> of a sophisticated solution, but that on its own, it still had flaws. The bitcoin blockchain was not the answer (Mycelia for music, n.d.). Recognising that music makers are the fabric of the music industry, Mycelia – Heap's team – is now developing *The Creative Passport*, a digital container aiming at holding verified profile information, acknowledgements, works, business relationships and payment mechanisms to help get music makers and their works linked and open for business. Using emergent DLT and featuring smart contracts, *The Creative Passport* plans to enable quick and easy direct payments and simplify collaboration from creativity to commercial partnerships (CREATIVEPASSPORT MTU, n.d.).

EY and Microsoft joined forces to develop a rights and royalties solution for the gaming industry. Their embedded smart contracts are designed to enable accurate and real-time calculation of royalty positions, providing enhanced visibility for recording and reconciling royalty transactions. The underlying trust network is built using the Quorum blockchain protocol and implements confidentiality of agreements across entities. Xbox's game publishers, who are participating, get improved speed and visibility. They can generate daily accounting accruals and use timely data to improve their forecasting (EY, 2018b)

**Seizing opportunities**

*Metered consumption and micropayments*

*Limitations of subscription and ad-based models – Subscriptions are limited by consumer wallet size and eclectic consumption behaviour; the productivity of ad-based streaming remains to be proven.*

There are basically four business models for distributing audio, video and other media content over the Internet –

- Free of charge – typically used by public services such as state-owned media outlets like ZDF/ARTE in Germany or the BBC in the United Kingdom.
- Subscriptions – grant users access to a service typically to listen or watch until they unsubscribe. They can listen or watch with no limits. The best example of such a business model is Netflix.
- Transactions – usually not charging users to sign up for the service or create a user profile. Instead, they pay based on the content they listen to or watch. This relates to movies and is also used for series, sports and events. iTunes is an example of such a transaction-based service.
- Advertisement – free for users, whereby they log in and stream music or videos in return for spending time watching ads. YouTube is the best example of such an ad-based service.

Many content distributors opt for a mix of business models, for example, subscriptions and advertisement as done by Spotify and YouTube, or for hybrid forms such as *freemium*, where teasers can be accessed free of charge but premium content only behind a paywall, as practised by most online newspapers and magazines.

Free of charge is intrinsically problematic. Then, there is a wallet-limit to the number of subscriptions an eclectic adult can take, while the younger generations are reluctant to pay for anything in advance. Finally, ad-based models are awkward, their rightsholders' remunerations cumbersome, their exploitation of users' data restricted, and their effectiveness circumvented by ad-blockers.

*Metered pay-as-you-go, real-time micropayment is the "natural" way ahead, but bundles would still be allowed, and consumer privacy and security must be respected.*

Transaction-based business models offer the fairer, most flexible and preferred remuneration process. They are widely used by gas, water, electricity, telephone and broadband providers, in transport (train tickets and highway tolls), and by financial institutions. They rely on (smart) meters, are easy-to-use (contactless smart cards), offer discount mechanisms (prepaid amounts and data packages), and can be bundled, monitored, reported and audited.

In media & entertainment, not only the transactions involve tiny amounts of money, but these minuscule sums must often be split among many rightsholders according to complex and dynamic rules, while the cost of the transaction process must remain affordable. Combining the functionality of tokenised assets and smart contracts should open the door to speedy and affordable micropayments.

Two exemplary developments. Lightning is a decentralised network using smart contract functionality to enable instant payments across a network of participants. It is meant to allow instantaneous payments, work across blockchains, be scalable and low-cost (Lightning Network, 2020). AdEx is a trust-minimised solution for digital advertising that aims at reducing ad fraud, improving ad budgets and protecting user privacy. The platform connects publishers and advertisers without intermediaries on a decentralised exchange and provides both parties with real-time reporting. AdEx payment channels solution allows micropayments for each ad impression – a unique benefit for advertisers and publishers (AdEx Network, 2020)

*Creativity, consumption and granularity*

*Track-based licensing – The granularity of licensed digital assets is increasing, typically from a concert to a song to a musical phrase, from a text to a title, from a film to a picture.*

Keeping track of all the music used in films or on television shows is a formidable task that requires vast and systematically updated computer databases logging the music composed for past and new productions. Cue sheets are used to make this immense task feasible. Without them, it would be impossible for composers and publishers to be compensated for their work. An accurately filled out cue sheet is a log of all the music used in a production. If there is more than one composer for an individual piece of music, or if the writer and publisher split their royalties on an other than 50/50 basis, this must also be indicated on the cue sheet as these are important factors in payment calculations. With the increase in independent producers and streaming operators, the filing of accurate cue sheets has become even more crucial to track the use of music (Broadcast Music, Inc., n.d.) and remunerate all the rightsholders of one film or one TV show.

Now that hierarchical tokens, trusted networks, smart contracts and micropayments are in sight, granular, track-based licensing will (soon?) be significantly facilitated. That will allow the licensing of one track of a film or even of one part of one track of a film, for the purpose of streaming it as it is or remixing it, or a world of new monetisation possibilities is opening.

*Micro-licensing – Real-time micropayments could support micro-licensing based on time, territory, channel or use.*

What is valid for the granularity of the media asset is also true for the granularity of the usage of that asset. Time, territory, channel and use can be split. The granularity of usage parameters will allow flexible and dynamic business models, increase revenues and amplify collaborations. Smart-contract-automated real-time micropayments are a condition; uncertainty around rights availability a consequence.

A crucial prerequisite for short-lived and granular content transactions is the ability to address and identify content quickly. However, the press and other industries dealing with digital content do not even have standard identifiers; e.g. there is no widely adopted, standardised identifier for images. The overhead and costs of manually assigning and tracking identifiers for them would be prohibitive. Auto-generated identifiers created algorithmically from the content itself could be a solution (ISCC - Content Identifiers, n.d.).

With the advent of DLT, the IoV is moving towards a trusted network of peer-to-peer transactions. In a multi-sided ecosystem, anybody may have a legitimate interest to generate or lookup an identifier for some digital content. Open and accessible standard identifiers that are specifically designed to manage small and sometimes transient pieces of digital media content will be essential for transactions in an increasingly heterogeneous media environment. They will replace proprietary identification systems and provide for a socio-politically acceptable implementation of Article 17 of the EU directive 2019/790.

*A secondary market for media assets*

*Peer-to-peer exchanges of pre-owned media assets – Prices in the primary market are usually set beforehand, while prices in the secondary market will be determined by the economic equilibrium between supply and demand.*

An ambitious theoretical promise based on a modest premise: one should be able to extrapolate fintech uses of blockchain to media and entertainment. In 2019, a nominal share is a digital file, and so is a song or a film. What applies to nominal shares might apply to .mp3 or .mp4. A company issues shares. The copy of a share is not a share and has no value. An author issues media assets. The copy of a media asset is not an asset and has no value.

A nominal share changes holder through a blockchain transaction. The blockchain transaction is immediately and transparently recorded into the shareholder register, a distributed ledger. The shareholder registrar knows who is holding the nominal shares and how they came to their holders. A media asset changes holder through a blockchain transaction. The blockchain transaction is immediately and transparently recorded into the fan register, a distributed ledger. The fan registrar knows who is holding the media assets and how they came to their holders.

First, the stock market sets the current price of a share; then, it exchanges that share. First, the secondary market for media assets sets the current price of a media asset; then, it exchanges that media asset.

*Next-generation engagement*

*Token-based direct interaction – Just like the issuer of nominal shares must be able to contact a shareholder, the issuer of media assets will be able to interact directly with the asset holders.*

Companies issuing nominal shares must conduct corporate actions. They must invite their shareholders to general assemblies, send them reports and proxies, and collect their votes. Artists publishing media assets should be able to engage fans. They should invite them to concerts, send them news and alerts, sell them merchandise in context, and facilitate their participation.

A media asset changes hand only against payment while the asset register is updated. Issues of media assets can be limited or unlimited. Current readers and players can read and play blockchain media assets, and existing online shops can sell blockchain media assets.

The previous paragraphs are a theory. They outline what could soon be technically feasible without considering yet business sustainability or societal frameworks. Typically, the concepts of privacy applying to nominal shares are not the same as the principles of privacy applying to the consumption of media and entertainment. The European General Data Protection Regulation (GDPR) that came into force in May 2018 is a case in point, the reconciliation of GDPR and DLT an object of research (for further information see Finck, 2019). A new way to manage online identities, consents, privacy and the right to be forgotten will be necessary to put the above-mentioned theory into practice.

*Collaborative creation – Distributed ledger technologies will not only mediate the contact between authors and consumers, but it will also support their active collaboration.*

In media & entertainment, fan engagement grows step-by-step. Publishers –

1. Present high-quality content on various media
2. Adapt same idea or content to various media
3. Enable customers to follow content from one medium to the next
4. Empower customers to discover content, get active with different media
5. Enhance customers' lives by triggering their active collaboration

Customers' loyalty and willingness to pay are directly related to real value – their engagement with content. Artists and producers have four aces in their sleeves. They can enrich and offer additional context, thrilling stories, virtual reality and useful services. They can interact and let customers play games, exchange among themselves, and connect with artists and productions. Then, they can embed promotions and transactions into video-players, sell in context, ease the buyer experience, offer augmented exposure to sponsors, and generate valuable audience data. Finally, they can add even more value by personalising and presenting relevant content across all touchpoints, tailored in real-time according to customers' profiles, momentary situations and predictions.

DLT enables a value-exchange protocol. What TCP/IP did for the exchange of information DLT will do for the exchange of value. Value lies at the heart of the blockchain; if there is no value involved in a process, then there is no need for trust and no need for blockchain. The mission of the IoV is to exchange any amount of value as quickly and fluidly as information is exchanged today. To truly understand the revolutionary potential of this technology is to appreciate how value and its exchange influence and regulate almost all aspects of media & entertainment. Value creation, measurement and exchange will remain the core of our industry and harnessing the IoV will be its most critical success factor.

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## Part B: Solving Challenges in the Media Sector with DLT

*Soichiro Takagi*

**The changing structure of the Media sector**

*Media and distributed ledger technologies*

Throughout history, media is one of the fields that have been affected drastically by technological development. Letterpress technology that was invented by Gutenberg in the 15th century transformed how religious ideas are transmitted among people. The invention of the radio and television enabled information to be transferred among people instantly. Since the 1990s, the Internet has been the main driver of influence, profoundly affecting how people create, transmit, and share information around the world, and consequently changing the structure of the media sector. Using the Internet, people can create and share information with a far more extensive range of audiences on a global scale. Anyone, not only professionals in the media sector, can exchange their views and opinions on social and political issues across distant locations and national borders.

While digital technologies are transforming the media sector, new challenges are arising. For example, "fake news", which aims at disseminating false information based on a specific self-interest, has become a social problem. On the other hand, the flow of information is curated by platform services such as social networking services, but people are not fully informed on how that curation is conducted. While the Internet has offered a broad range of opportunities to harness the potential of people to create, transmit, and share information, new challenges are also arising in the media sector.

In this context, this part explores how DLT and blockchain technologies can contribute to solving new challenges in the media sector. It is worth exploring because the central advantages of blockchain/DLT are related to "trust", and the new challenges in the media sector are mainly related to the lack of trust, which is shown in the following sections of this part.

The next section is structured as follows. The remainder of this introductory section clarifies what are the main values of media in modern society and shows how the Internet is changing the structure of the media sector. Section 2 presents and discusses challenges that are caused by the Internet revolution. In section 3, the benefits of using blockchain/DLT, in general, are summarized by using a framework. Section 4 discusses how the benefits of using blockchain/DLT can solve challenges in the media sector. The final section concludes the discussion.

*The value of media in modern society*

When people refer to "media", it has two meanings depending on the context. The first one is "medium" of information, which supports conveying information from person to person. It has taken the form of materials and methods such as stone, paper, radio and television, which have worked as a medium of exchanging information. The other is the role of "mediation" of information which is the activity to collect, transmit, and share information usually curating and editing the information to fit social demands and the interest of audiences.

Whether it is a professional media service or an amateur journalist, the valuable function of media can be presented as:

1. Conveying information
2. Curating information
3. Presenting discussion points

4. Providing a public space for discussion

The first is conveying information, which is the transmission of information from one place to another, including the creation of content to describe facts. It can be observed in various situations such as political activity, disasters and news about local retailers.

The second is curating information, which is the selection of information that should be delivered to audiences. Curation is affected by a variety of factors, such as the constraint of resources like the space on newspapers, the writers' interest, the interests of society, and possibly the interests of sponsors and advertisers.

The third is structuring discussion points, which is the editorial function suggesting how the information should be interpreted and what should be discussed by audiences. It is done partly through the curation of the information, and partly by editorial comments and articles.

As an extension of offering discussion points, the fourth is providing a public space for discussion, so that people can communicate and discuss social topics to deepen their understanding and occasionally build consensus on the direction of action. This is related to the concept of the 'public sphere', that is the place where public opinion is formed. (Habermas, 1991).

From the first to the fourth valuable function of media, the tasks become more complicated and include normative interventions. In other words, they shift from focusing on the simplest form of media as the transmitter of information to becoming a subjective activist in society, such as seen with journalism.

*Macro-level changes in key attributes of media*

In the last 20 years, the emergence of the Internet has dramatically impacted the media sector.  shows the change in key attributes of media at a macro level comparing newspaper, radio/TV, and the Internet. The flow of information shifted from "One to N (several people)" to "N to N". This shift reflects a change in key resource constraints to disseminate information.

| | **Newspapers** | **Radio/TV** | **Internet** |
|---|---|---|---|
| **Flow of information** | One to N | One to N | N to N |
| **Producer of information** | Professionals | Professionals | Anyone with an Internet connection |
| **Key resources** | Paper, Printing machinery, Distribution capacity | Radio wave license, Broadcasting facilities | Internet connection, Devices |
| **Reach of information** | Limited to logistical boundaries | Limited to radio wave boundaries | Limited to Internet connections |

*Table 5: Changes in key attributes of media*

In the newspaper age, papers, printing machinery, and distribution capacity played important roles as key resource constraints. Radio/TV also requires similar resources such as radio wave licenses and broadcasting facilities. However, in the Internet age, one only needs an Internet connection and low-cost devices to disseminate information, such that a vast number of people have begun creating and publishing information.

On the other hand, the reach of information has also expanded drastically alongside technological development. The logistics of physical papers has limited newspapers. Content of Radio/TV has been transmitted to the extent of the reach of radio waves. However, information on the Internet can be transmitted globally as long as audiences are connected to it (although language differences are working partly as practical barriers to information flow). As a result, the role of collecting and disseminating information has been drastically expanded from only a limited number of professionals to a wide range of participants, including ordinary citizens. The amount of information which is circulating in society has also exploded.

*Key providers of media value on the Internet*

When we look more closely at who is playing essential roles in the valuable media functions mentioned above on the Internet, it can be analysed according to the different tools they use, as shown in table 6.

| | **Web-news** | **Blogs** | **Social Networking Services (SNS)** |
|---|---|---|---|
| **Conveying information** | Professional media person | Anyone | Anyone |
| **Curating information** | Professional media person | Not curated | Platform services |
| **Presenting discussion points** | Professional media person | Not provided | Autonomously structured, influenced by platform curation |
| **Providing public space for discussion** | Professional media person | Not provided | Autonomously provided, influenced by platform curation |

*Table 6: Key providers of media values on the Internet*

In web-news media, the four valuable functions of media are provided by professionals of the media sector. This has not changed substantially since traditional media such as newspapers and televisions. On the other hand, blogs can already be written by anyone who has an Internet connection. The written blogs are posted without curation, and usually, no one takes the role of structuring discussion points or offering a public space for discussion. Thus, audiences have to search for information matching their interests from a vast number of blogs online.

Emerging social media platforms such as Twitter and Facebook were designed to solve the curation problem by managing information based on the social connections of users. Curation by Internet search engines, such as Google, has also become more important as the amount of information has exploded, making it difficult for people to find what they are looking for without the assistance. Therefore, important functions of media are provided more and more by platform services such as Google, Facebook, and Twitter. Regarding presenting discussion points and providing public spaces for discussion, it is generally autonomously provided by users but greatly influenced by the curation of platforms, as platforms control what information is presented to each user.

One of the problems in platform-centred media is that the curation by platforms is conducted by "black box" algorithms, which include various variables such as users' preferences and social networks. It is difficult to audit the algorithms and compare personalized outcomes. This issue raises concerns on trust in new media, compared to traditional media.

The emergence of the Internet has made citizens major players in the media sector, and the distinction between producer and consumer of information has become vague. Anybody can collect, produce, and disseminate information and opinions on a global scale and at a low cost. This has caused an "explosion" of information made it difficult for audiences to find important information. Platforms such as social media were introduced to solve the problem by curating information based on social networks, but several problems arose, as shown in the next section.

**Key challenges in the modern media sector**

As more information is created and published not only by professionals but also by the general public, the variety and quantity of information have been widely enriched in society. Moreover, the one who knows a topic best can provide valuable information. For example, reviews by actual users of washing machines and refrigerators are sometimes more valuable than reviews by professionals who have not actually used the appliances in their daily life. However, the impact of the Internet on the media sector also caused several challenges, as shown below.

*Fake news*

As any people can publish and disseminate information through websites, weblogs, and social media; fake news has become a social problem. Fake news can be defined as intentional dissemination of false information with a certain purpose. It is sometimes based on a political goal or interest, or simply to cause confusion in society. Fake news occurs because there are no mechanisms to check the quality of information at the origin, and by people's intrinsic willingness to disseminate information, which is amplified when the information is surprising.

*Disruption of the professional media sector*

As people spend more time on social media consuming information that is generated by other users, advertisement expenditure has been shifting from traditional media to Internet platforms (social media). Google's advertisement revenue reached 95.4 billion USD in 2018 compared to all U.S. newspapers earning 16.5 billion USD (Fox, 2019). However, web services and social media companies such as Google or Facebook only convey information on their platforms, and do not bear the responsibility to write, edit, and check the information accuracy as the traditional media sector does. As the traditional media sector declines, it is becoming difficult to maintain jobs for such professional editors and journalists.

*Echo chamber*

As a result of expanded sources of information online and social media's curation prioritizing 'click' rates and platform 'stickiness', people tend to be exposed only to views similar to their own. This phenomenon is called "Echo chamber" or "Filter bubble" (Pariser, 2011). This is caused by various web services from search engines, web news to social media platforms as soon as they personalize content based on users' preferences and past activities. As a result, people are wrongly inclined to feel as if all others think as they do.

*Online advertisement fraud*

As mentioned earlier, advertisement expenditure is shifting from traditional media to Internet services. However, Internet advertisement is facing another problem: ad fraud ('Ad Fraud', 2020). It occurs when the number of advertisement exposures to audiences is manipulated and reported to advertisers who then must pay excessive fees for ads. In other cases, online advertisement is not at all displayed for viewers but hidden behind a website and counted as if they were actually viewed by audiences. Ad fraud is estimated to reach $50 billion by 2025 (Shields, 2016). This is caused by the difficulty to trace activities online, compared to newspaper adverts which can easily be checked by advertisers through printed papers.

Several challenges are arising as the media sector changes. The common and essential factor behind the challenges is the lack of trust caused by the explosion of the number of players creating and disseminating information. The central topic of this chapter is how these challenges can be solved by blockchain / DLT; therefore, the next section explores the benefits and advantages of using the technology.

**Benefits of blockchain/DLT and general use cases**

There are several benefits of using the blockchain instead of conventional relational database (RDBMS) management systems. In this chapter, the benefits are summarized according to three attributes: Anti-tampering (A), Value circulation (V), and Traceability (T).

*Anti-tampering (A)*

Conventional information systems protect information from being tampered with by building firewalls and strict user-authentication techniques. On the other hand, blockchain/DLT can protect information from manipulation by linking data from its origin to its latest status and by auditing the data in transparent settings. In other words, blockchain/DLT can ensure the integrity of data even if the information is shared with several anonymous users.

Through this attribute, enterprises can reduce the costs of securing data against tampering. This means that protecting the integrity of data is no longer a core function of some organisations, and its role can be delegated to the blockchain network.

A typical use case of anti-tampering is the storage of educational records, such as practised by the University of Nicosia (University of Nicosia, 2015) and the Massachusetts Institute of Technology (Massachusetts Institute of Technology. n.d). They store the key information of the education certificate (typically a hash value of certificate) in the Bitcoin blockchain, thus ensuring that the digital certificate is genuine and not counterfeited.

*Value circulation (V)*

Most blockchain/DLT platforms provide a function to build a linkage between value and specific entities, such as Bitcoin and Bitcoin owners. Given that blockchain/DLT does not depend on the trust of specific organisations or authorities, blockchain/DLT enables everyone to create a system to manage value. These systems can capture, record and symbolise various types of value and transfer those values across diverse stakeholders. Typical usages are cryptocurrencies such as Bitcoin, but many types of value, such as electricity and land ownership, can be managed with blockchain/DLT. This attribute also works to create various incentive mechanisms driven by the issuance of tokens.

Various examples using this attribute can be observed. For example, Ant Financial is providing a blockchain-based inter-exchange system between mobile payment services. They constructed a blockchain-based system to connect Alipay and GCash in the Philippines, so that users of each service can send money across different mobile payment platforms. In another example, Earn.com integrates Application Programming Interfaces to micro-payments and allows to capture the value of small data and make them tradable between anonymous stakeholders. As an extension of embedding payments in M2M transactions, electricity is also one significant field using blockchain/DLT. Digital Grid, a Japan-based electricity technology company, is providing an ecosystem in which houses and buildings can exchange solar-powered electricity by using blockchain which manages the flow of electricity and coordinates market transactions of electricity (DIGITAL GRID Corporation. n.d.).

*Traceability (T)*

The trust in the integrity of information in blockchain/DLT is ensured by the logical linkage of transaction data from their origin to their present state. This historical management of transactions enables one to trace back how information originated and was transferred across stakeholders.

For example, Everledger traces how the ownership of diamonds is transferred across many owners. Walmart is using blockchain/DLT to trace the transactions of foods to ensure that the products they sell are genuine and safe. On the other hand, the UK government conducted a trial to use cryptocurrency technology for welfare payments to check that the assistance is provided as intended by legislation. In another instance, Startbahn created a system which manages the trade of artworks, so that the original creators can obtain a certain portion of the value generated in the secondary market.

As seen above, the benefits of using blockchain/DLT are summarized by three attributes, and cases utilising those attributes are observed in various sectors. The next section discusses how these benefits can be applied to challenges in the media sector.

**Solutions for the media sector**

As seen in Section 2, many challenges in the media sector are related to a lack of "trust", therefore these challenges could be solved by blockchain/DLT-based solutions. The following argument discusses how blockchain/DLT can solve the key challenges introduced in Section 2, considering the benefits of blockchain/DLT as shown in Section 3.

Against fake news, the central approach is to minimize the incentives to disseminate false information and motivate people to share only truthful information. As truthful information has a certain value for society, "Value circulation (V)" approaches can be used. Typically, tokenisation can be considered, such as seen in its primitive form in Bitcoin, where token issuance motivates people to contribute to maintaining the trust of information in Bitcoin payments. Examples of this approach are observed in Steemit[23] and ALIS[24], which issue and use tokens to incentivize people to create and share information highly valued by others. However, it is worth noting that incentivization by token issuance should be carefully analysed and designed to assure that its value formation is sustainable. Another method is to store a complete record of information history by using Anti-tampering (A), and Traceability (T) approaches so that one can trace back how fake news is disseminated. However, it should be carefully considered in order not to sacrifice privacy and the right to free speech.

The second issue was the disruption of the professional media sector. A Traceability (T) approach could be used to securely store and share how much each article is viewed and valued by others, for the author of the information to be appropriately compensated. It is also possible to include evaluation mechanisms by audiences. A Traceability (T) approach is better than tokenisation, considering that

[23] Steemit - https://steemit.com/
[24] ALIS - https://alismedia.jp/

the flow of information from professional writers to audiences should be limited to certain participants. It is a particularly reliable solution where platforms are earning excessive rent and writers are not appropriately compensated.

As seen in the first section that analyses the important role of platforms as curators of information, the key to the solution for the Echo chamber problem is the behaviour of the platform providers. One should be focused on enhancing the trust in and transparency of the algorithms curating information for users for the audiences to understand and check how information is selected and displayed to each user. The Anti-tampering (A) attribute could be used to store the curating algorithm and store and compare the results of curation across different users.

Lastly, online advertisement fraud can be solved by two approaches: Anti-tampering (A) and Value circulation (V). With Anti-tampering, displayed ads or their identifiers can be stored from users' web browsers into blockchain/DLT, and the payment of advertisers can be based on the stored information. This approach depends on the functionality of web browsers but can reduce the risk of manipulated records of advertisement. On the other hand, as an instance of the Value circulation(V) approach, Hakuhodo, a Japanese advertising agency, is creating a solution which converts digital advertisements into digital assets so that users can proactively collect digital ads rather than passively view displayed ads (PR Newswire Association LLC, 2019). In this case, collected digital ads can be used, for example, like discount coupons for products of the advertisers.

These are examples of approaches for solving challenges in the modern media sector, and other solutions can be envisaged considering the three benefits of using blockchain/DLT.

**Conclusion**

As seen in this chapter, the media sector is in the middle of a transformation driven by the Internet revolution. As technology empowered people to create, collect and disseminate information, the media sector is facing a very different ecosystem involving a proactive public and not just media professionals. Alongside this transformation, new challenges are arising to make the media space trustable and accountable.

Key advantages of using blockchain/DLT are related to enhancing trust, such as seen in anti-tampering, value circulation and traceability. Therefore, blockchain/DLT can contribute to solving the challenges. However, it should also be noted that blockchain/DLT is only one of the components of societal ecosystems, and that blockchain/DLT alone cannot fully solve the problems. The challenges in the media sector relate to a wide range of social elements such as mediation, incentive, evaluation, industry, and occupation. Trust in 21st century media should be reinforced by the full combination of business, legal and technological solutions.

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# Chapter 5: The IoV and E-Commerce

*Peter Bambridge, Chris Wyper, Antony Welfare, Geri Cupi*

E-commerce has changed tremendously since new business models were introduced at its beginnings. Many could not have predicted that a company that was one of the first to sell books online would become the largest marketplace in the world.

The Internet revolutionised e-commerce and empowered consumers to gain more choice, better deals and order products with a few clicks of a button. With all these benefits, there have also been negative consequences. Consumers' data is being exploited. Consumers are also wasting more in our linear economy where products new products are consigned to the garbage pile after being used for a limited time. This is causing greater pressure on the Earth's limited resources.

This chapter focuses on how the IoV powered by blockchain can lead to the next level of empowerment for consumers, whilst mitigating some of the negative connotations in the arena of e-commerce.

This chapter consists of three parts. Part A is written by Peter Bambridge and Chris Wyper. In their Part, they focus on how the IoV can address e-commerce business models in the areas of Loyalty, Direct to Consumer, Servitisation, Sustainability, Data and Self-sovereign Identity. All these areas have a direct impact on the evolving role of e-Commerce business models and how these will affect consumer markets.

Part B is written by Antony Welfare. This Part focuses on the importance of e-commerce marketplaces and how the properties of Trust, Transparency and immutable data, that are brought forth by blockchain can lead to a fully functioning decentralized marketplace.

Finally, Part C, written by Geri Cupi focuses on how the IoV can empower new business models in e-commerce focussed on the circular economy. The section includes case studies on the fashion industry before moving on to discuss the importance of Non-Fungible Tokens empowering new business models.

Feedback for this chapter was provided by Stylianos Kampakis.

## Part A: The IoV in Consumer Markets

*Peter Bambridge, Chris Wyper*

### Introduction

The core principle of the IoV is the fast and easy transference of value between two parties, cutting out middlemen or eliminating third party costs in the process. In the e-commerce world, the transference of value occurs when consumers "pay" for the products they are "buying". Credit card, and online payment systems like Paypal, are the most common methods for transferring value, certainly in a consumer world. However, these systems still rely on an intermediary to complete the transfer.

Most e-commerce platforms today still rely on these traditional forms of payment, but some e-commerce platforms are beginning to accept cryptocurrency as payment - e.g. Shopify. While much is written about cryptocurrency, it is not yet widely adopted across e-commerce as a medium for payment; however, cryptocurrency represents an opportunity to facilitate the quick transference of value.

This is easily understood when one considers cross-border settlement transactions that are currently both slow and relatively costly. The role of technologies such as blockchain in disintermediating such processes is well recognized and opens the door to quicker and more cost-effective processes.

There is a wide range of digital transactions where DLT can facilitate such value exchange, from loyalty points to shares, and from music to art.

While value is often expressed in monetary terms (assets, stocks, products, etc.) it can also relate to the social or consumer value that customers receive when buying products or services. In this case, value is transferred via things like time saved, feel-good customer factor or reducing environmental impact. These may be less tangible than the transfer of money, but in today's world, they are no less important.

No matter whether we are talking about monetary, social or customer value, the two core issues that must be addressed are TRUST and TRANSPARENCY. Traditional e-commerce payment methods have a level of surety; if a customer uses a valid credit card, the seller will get paid, and in return, the customer trusts that they will get the goods they have paid for. The supporting banking system provides a level of, although not infallible, support. In addition, consumers today want validation and greater awareness of a product's authenticity, manufacture and lifecycle.

According to Tapscott and Tapscott (2018), the IoV is fundamentally enabled by blockchain. Consequently, when considering new e-commerce business models enabled by the IoV we need to examine the impact blockchain has on providing sufficient trust and transparency to enable a quick transfer for value, whether monetary, social or perceived customer value. Across Retail and Consumer Goods Industries, collectively known as Consumer Markets, the areas that we see as emerging include: Loyalty, Direct to Consumer, Servitisation, Sustainability, and the areas of Data and Self-sovereign Identity. Each of these areas are considered in turn.

### Loyalty

Loyalty programmes have been around for a long time in industries such as retail, hotels, airlines and credit cards. These programmes are all designed to try to build customer loyalty by rewarding the right behaviour. Establishing loyal customers has always been important given the frequency of repeat business, and average basket size; driving repeat business is critical. Most of these programmes have been focused around the interests of the company by geography and have been engineered to retain the 'value' in the rewards to only be consumable within their own business.

Some companies have found that running such loyalty programmes can be expensive and with questionable returns. In challenging economic times, it is easy to lower the level of rewards, but that can lead to a significant drop in engagement.

What is really needed is a more cost-effective model to run loyalty programmes and allow the currency of the reward to be utilised across brands/companies/channels/geographies. This is where blockchain can help enable a new generation of loyalty programme.

Blockchain is well suited to holding secure information about transactions that generate rewards and providing a platform to allow rewards to be spent only once. Combined with the management of identity, this can then become a valuable source of insight and marketing opportunities.

Blockchain could be used to simply keep track of virtual points, or to manage tokens as the reward currency. By overcoming the complexity of traditional loyalty schemes and driving higher engagement and redemption rates while reducing costs per transaction. Blockchain can be used to establish a new approach to loyalty programmes.

Most consumers are members of many different loyalty programmes (the average is over seven schemes per consumer in the US), carrying multiple loyalty cards is a nuisance, and does little to encourage engagement. Having blockchain-based loyalty tokens that are interoperable across loyalty schemes would significantly affect this. This approach can also aid the problem of points expiring over time and enhance the overall customer experience by increasing flexibility.

Smaller organisations are not excluded from such opportunities to engage in blockchain-enabled loyalty programmes, as costs are reduced. For businesses running such schemes, fewer people would be required to run the system and monitor the liabilities. Online sites can use such reward schemes to drive repeat business and increase total customer value. By offering such a loyalty scheme for customers across multiple companies provides increased exposure through network effects.

An excellent example of this is qiibee[25], which lets companies create loyalty coins on a blockchain.

**Direct to Consumer**

Although there are similarities between the Direct to Consumer (D2C) and Business to Consumer (B2C) model, the key (simplistic) distinction is that in D2C, the manufacturer is selling their products directly to the end customer without the need for retailer intermediaries. In reality, however, the lines are blurring between manufacturers and retailers, but for simplicity, we will focus on the pure D2C model, manufacturers selling to consumers via e-commerce channels.

Indeed, the evolution of e-commerce coupled with disruptive technologies has given rise to a myriad of new entrants selling everything from mattresses, razors, wine, groceries and fashion alongside the large, traditional consumer organisations such as Unilever or P&G. Products are sold to consumers either on a company's e-commerce site or via a storefront on online marketplaces such as Amazon, eBay or Alibaba.

For consumer organisations, D2C offers a range of benefits such as retaining more profit (no retailer middleman), access to customer data, a greater degree of product personalisation and more scope

[25] qiibee - https://qiibee.com/

for testing new products. But D2C companies still face a range of challenges that mirror B2C models - namely transaction fees, cost of returns, and complexity associated with running different models.

Blockchain offers the potential to change D2C e-commerce business models, driving value for customers and retailers in several ways:

- Leveraging cryptocurrency as a method of payment can reduce operational fees for sellers and in return, lead to lower prices for consumers.
- We are redefining loyalty programmes from point to token-based, to unlock the value held in legacy loyalty programmes. Blockchain offers a more affordable way to store and use rewards which in turn can reinforce brand loyalty, leading to increased sales and customer satisfaction.
- A greater degree of trust and transparency than in a traditional D2C model by providing verifiable evidence of product provenance and authenticity. This reduces the risk of counterfeiting and also provides evidence of product composition to ensure product safety and quality, driving brand equity. Value, in this case, is driven based on the assurance that the product is what it says it is and also customers are not put at risk.
- By creating a digital footprint of product warranties via blockchain that reduces administrative overhead and also supports effective and targeted product recall. Value, in this case, is the time saved by both the seller and buyer as well as the minimising the costs associated with the recall process by targeting only affected products.
- Simplify and connect the end-to-end supply chain to reduce administrative costs, save time associated with bureaucracy as products move from suppliers, through manufacturing to consumers. Smart Contracts can be leveraged to redefine e-commerce supply chains to speed up processes, reduce costs and ensure continuity of supply.

Blockchain presents a number of opportunities to enhance and open up new ways of doing business online. At the core, value is derived from reducing the number of links in the chain and in doing so, drive down costs that aid customers and buyers. Ultimately, increasing trust & transparency across the supply chain is critical to be able to deliver viable D2C models and blockchain has the capability to help re-define how these supply chains work and in turn, open up different ways of selling in a D2C model.

**Servitisation**

Servitisation is the process of turning a conventional consumer product into a product-as-a-service. In the consumer world, there are many examples from meal-kit subscriptions to product replenishment, from clothing subscription services to product rental. None of these ideas are new, but with e-commerce, the models have been given a new injection of life and more importantly, an ability to do things differently. Blockchain and distributed ledger technology have the opportunity to enhance these models further by focussing on trust and transparency to underpin and quicken the transference of value in the IoV.

To illustrate this, let's look at the example of online high fashion rental business models. This is fundamentally a B2C model whereby customers can either rent single items for a designated period or sign up to a subscription service which gives them a certain number of items in a given period. In this case, value is transferred for a limited time until it shifts back to the buyer. Given the relatively low barriers to entry, consumers are also increasingly able to connect and rent directly with other consumers (C2C), thereby deriving an income from their assets, namely their clothes.

In most cases these models follow the standard e-commerce approach, namely ‘find products’, ‘add to basket’ and then ‘pay’ via credit card or online payment methods such as Paypal before the products are shipped to the customer. Along the way, banking intermediaries are taking fees for processing the transaction, and there is an inevitable delay in terms of value being transferred between buyer and seller.

While some measures are in place already to prevent fraud, the risk still exists that a seller may rent an expensive item for a fraction of the retail cost and may never see the product again. Of course, the flip-side of that argument is that customers trust the product they are renting is indeed genuine, either in terms of the brand name or how the product is manufactured (e.g., there is no leather, fur or is made from sustainable cotton, etc) - in other words the product is as advertised!

Trust and transparency are at the heart of driving new or emerging business models and blockchain, as a fundamental enabler delivering the IoV, is critical in making this happen. There are several ways in which this could occur:

1. **Building verifiable customer records**. Blockchain could be used to hold a verifiable customer record that could be shared across platforms. This could reduce the additional vetting processes some sellers take before allowing customers onto their platform, or it could provide evidence. For customers, it potentially opens up new sellers in different markets, increasing the range of products that could potentially be accessed. Throw in the use of cryptocurrency as a payment mechanism, and sellers have an increased level of trust or put another way, the level of uncertainty decreases.
2. **Building verifiable supplier records**. For customers, transacting with sellers is also based on trust, hence blockchain holding verifiable supplier records reduces the uncertainty that you are engaging with a supplier that either isn't reputable or products are not what they appear to be. For larger B2C organisations this may be less of an issue, but if you are a consumer renting your clothes from another consumer, having verifiability helps to alleviate potential trust issues. For sellers, it potentially opens up new customers in different markets by providing a level of transparency and verifiability to you - that you can be trusted.
   Verifiability, in this case, is about the surety of the transaction. Reducing the uncertainty that I am going to be paid as a seller, and I will receive my product as a buyer, and then as a seller, I get my products returned.
3. **Providing product transparency and traceability**. Blockchain can also help to extend this model by providing additional information about the product. This could range from provenance (where it was made), authenticity (is it real) and product composition (does it have leather, real fur, additives used, etc). Customers are placing increasing emphasis on the non-monetary value they receive from companies they interact with. Having visibility into where and how products are made helps align with their personal values and world view.

Blockchain, coupled with virtual currencies, can be used to enhance and extend the current rental e-commerce model, whether B2C or C2C. Value transference can happen on several levels, whether it's:

- Use of cryptocurrencies to eliminate the middleman between buyers and sellers
- Helping to increase the scope and reach of rental models, thereby reducing the impact on the environment by making fewer clothes and supporting the broader aims of the circular economy, in effect creating a transfer of social value in the form of less waste and lower consumption of resources.
- Improving customer perceived value, in this case transferring **time** back! As one customer indicated, she didn't have to spend time shopping…..she did it to "make her life easier at work".
- Bring a basis of confidence and trust between parties that have not previously dealt with each other.

As we increasingly move from an ownership to a rental model, and products as a service, the IoV can help scale existing models by connecting buyers and sellers on a truly global level, whereby individuals can compete with much larger companies, potentially simplifying and reducing the cost of doing business.

**Sustainability**

Sustainability is all about the ability to maintain existence, whether that is through reuse, recycling or reduction in consumption. The environmental footprint that an enterprise generates is a growing area of concern for consumers, brands, manufacturers, and retailers, in fact, for the entire supply chain.

Sustainability covers multiple dimensions including social, environmental and economic performance. In the Unilever Sustainable Living Plan, the core belief is that business growth should not be at the expense of people and the planet. In Marks and Spencer, Plan A (because there is no Plan B) is about building a sustainable future by enabling customers to have a positive impact on wellbeing, communities and the planet in everything that they do. These examples are being followed with interest by the many in the industry. The question is, can emerging technologies such as blockchain be adopted to help deliver such benefits, and illustrate the improvements being made.

Blockchain has a vital role to play in enabling sustainability in many areas, including the following:

- Tracking materials in garment construction
- Reducing waste in production processes
- Reducing water consumption in production
- Tracking carbon footprint
- Tracking the use of plastics in the supply chain
- Enabling the Circular economy
- Combating counterfeit goods
- Providing product provenance and authenticity

For enterprises, all these areas can contribute towards a strengthened sustainability proposition through improved efficiency, reducing waste, packaging, materials and water consumption, while lowering the carbon footprint. By also taking steps to address product authenticity, share provenance information and reduce counterfeit goods, enterprises can evolve the perception that consumers have of their brand and their business. Increasingly consumers are looking for products that align with their beliefs and lifestyle while also addressing their needs for convenience, reliability and safety.

So the next question becomes: How can blockchain and IoT help enable solutions to facilitate addressing the needs in each of these areas? There are multiple layers to the answer to this question, including providing the following:

- An immutable audit trail of events over time that can show the history of product movement throughout the supply chain, enabling product traceability/transparency and influence the shopper's buying decisions
- Certification of product provenance and product authenticity
- A platform for recording the recycling of products/packaging, and reducing the overall usage of plastics
- A platform to manage the tokenised incentivisation to help influence consumer behaviours and buying decisions cost-effectively
- A platform for a new generation of loyalty systems to incentivise the right behaviour

If we think about value in an environmental sense, the social value of using fewer resources and being more efficient may be more critical to the planet than the commercial value. A great implementation of this concept is Poseidon[26], which uses blockchain to track carbon footprint.

**Data**

Consumer industries have never been short on data, but e-commerce is a business model founded on data. Much is written about the use of machine learning and AI to identify patterns, make recommendations or even use digital assistants as part of the e-commerce customer journey. Of course, all of this relies on and generates huge volumes of data. Many if not all of the emerging e-commerce business models, such as subscription or new rental models, rely on the use of AI to learn, adapt and refine the products offered as part of the service. In doing so, retailers learn more about their customers, targeting them with more relevant products in the hope of driving more sales.

The use of technologies such as AI are helping to drive customer value in the form of time saved. In applying AI and machine learning to customer and product data (size, style, fit, colour, etc.) retailers can deliver the right products, tailored for customers without customers having to spend time shopping or returning clothes that are not suitable.

Technologies such as Blockchain have essentially risen to prominence, much like AI or machine learning, because of the importance that is now placed on data across every corner of commerce. Blockchain and AI use data in different ways, but the combination of the two could potentially extend or create new e-commerce models. If companies or even individuals can gain access to a wider variety of data that is currently out of their reach, either for regulatory or competitive reasons, they could drive deeper customer insights, better align supply and demand or even open up new avenues for engaging with customers.

To achieve this democratization of intelligence, blockchain can be used to control access to protected data, permitting data scientists to run their algorithms without exposing any of the underlying information. In this case, e-commerce companies could earn revenue from renting out their data or they "open-source" innovation to highlight new insights or opportunities to enhance the e-commerce offering. Leveraging blockchain to act as the security layer minimises the level of trust needed between different parties and can stimulate a new era of openness, innovation and data sharing.

The rise of e-commerce has led to customers freely handing over their personal information to retailers with very little thought about how it is used. The same is also true from retailers, large and small, who use market-place platforms such as Amazon or Alibaba, to sell their products, although, in reality, it’s a case of accept the terms or else you can't use the platform! Building on the security theme discussed above, blockchain represents an opportunity to restore the control of data to the "rightful owner":

- **Customers**: building e-commerce platforms on top of blockchain offers enhanced security and privacy with no central power owning the data. Customers are free to use or sell the data to e-commerce companies if they wish. In this case, the customer behavioural data has a value that was mostly given away by the customer. Still, by leveraging blockchain value transference can occur, depending on what the customer values in return!
- **Retailers**: Using an e-commerce marketplace usually means that access to customer behavioural data is dependent on the marketplace provider - the retailer does not own it!

[26] Poseidon - https://poseidon.eco/

Blockchain offers the promise of restoring ownership into the hands of the retailers, thereby reducing the cost of acquiring the data and driving more equitable competition.

Blockchain can drive the advancement of e-commerce business models by opening up access to valuable data sources in different ways and by providing the security backbone to ensure trust between parties. Value can be created, not just by selling data, but also by encouraging innovation without breaching data protection or impacting competitive advantage.

**Self-sovereign identity**

As there appears to be some confusion around the meaning and role of Self-sovereign Identity (SSI), it makes sense to start with a simple definition, before getting into the key role that SSI plays in enabling many of the aspects of the IoV.

SSI is a model used to manage identities in a digital world, where businesses and individuals can control their personal information, where it is held and how it is used.  Identity is no longer just a passport issued by the government.

Storing SSI on a blockchain, and sharing that information when needed, disintermediates the traditional role of third parties in trust validation and provides the self-sovereign control. This personal information can then be used to identify participants in transactions. Decentralized digital identity is not new; the concept has been around since the 1970's, what is relatively new is the potential use of blockchain to help facilitate it.

SSI can be a key enabler of new model approaches in the area of e-commerce. By taking control of their SSI, businesses and individuals can control what information they chose to share, and with whom they chose to share it. This is a key part of establishing trust.

SSI provides efficient control of private information, rather than handing over all their data, knowingly or otherwise, to third parties who may then use it for their purposes or even sell it on to others. The reality is that online, if you are not paying for a service, you are the product, and paying for it with your data (such as on the major social media platforms).

The burden of managing personal data passes to the individual, who then also has to consider it's security.

The evolving framework of regulatory models such as the EU's GDPR, the US Privacy Act and Federal/State laws, are establishing compliance requirements that also must not be overlooked.

For further information about the evolution of identity, please refer to Allen (2016) that includes the famous 'Ten principles of Self-sovereign Identity'.

Regarding the IoV, identity is key if transactions are to be trusted.

- In Loyalty, being able to identify the individual and build their profile uniquely is foundational. The use of marketing techniques to drive the behaviour of consumers incentivised by loyalty hinges on recognizing the consumer and what segments they belong to.
- In Direct to Consumer, the individual becomes the direct channel for the product or service, so again their identity is critical. Building a history of transactions and subscriptions rapidly becomes a valuable source of insight.
- In Servitisation, the use of verifiable customer records and supplier records are inherently based upon unique identity. To allow access to the information on transparency and traceability needs to be managed so again is dependent on secure identity.

- In Sustainability, identity is essential because rewarding the right behaviours requires clear identification.
- In Data, unique identification of the individual and the organization are critical elements of the underlying data infrastructure and used to collate and analyse this data into information.

Identity is vital to the security of information and ensuring accurate and attributable information.

**Conclusion**

The IoV may be a relatively new concept and continuing to evolve, but it is clear that it is here to stay. Emerging technologies such as blockchain have a critical role to play in enabling this exchange of value.

While there are multiple blockchain platforms on the market today, this will change going forward through consolidations, failures and technology breakthroughs. In Consumer Markets, the winning platforms will be the ones that effectively address the areas of Loyalty, Direct to Consumer, Servitisation, Sustainability, Data and Self-sovereign Identity. All these areas have a direct impact on the evolving role of e-commerce business models.

By briefly addressing each of these critical areas in this article, we have attempted to bring some clarity to the evolving role of the IoV, and how it is already starting to change the world of the consumer, and the entire Consumer Market.

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## Part B: Marketplaces and the IoV

*Antony Welfare*

Marketplaces are one of the oldest business models in our civilization. We have been bartering and exchanging goods for hundreds of years. With the advent of the IoV, we can now use this to power the next revolution.

**Blockchain powering the new marketplace model**

Blockchain as a marketplace is a very interesting concept. On the one hand, a marketplace built on blockchain technology makes complete sense – after all blockchain is about decentralisation and removing the middlemen. On the other hand, marketplaces today are globally complex beasts, which need significant management and administration.

Of particular interest is when looking at the reality of servicing a marketplace and the high customer expectations set by the current retail world leaders. Many questions affect customer services, delivery, marketing, quality and many other issues.

Blockchain-based marketplaces will grow (and there are already ones operating) but will they become global giants, with extensive product ranges? This will undoubtedly be difficult to achieve, given the current marketplace giants.

Amazon and Alibaba are founded on two key aspects, which are customer service and extensive product ranges. These are critical to the success of these marketplaces and something tough to get right with a blockchain-based decentralised marketplace.

We will see many smaller blockchain-based marketplaces grow, focused on a particular product or range, over time these could merge and grow into a global marketplace – it will be interesting and exciting to see this world progress.

*Marketplace for everything*

There are significant challenges for a marketplace built with blockchain technology, but there are also an unlimited number of options for a marketplace built on blockchain technology

The current marketplace landscape includes (remember that we include services as well as products in the marketplaces sector) Amazon, EBay, Alibaba, Uber, Air bnb etc, are all marketplace giants who can be changed by blockchain technology.

The significant challenges for a successful blockchain-based marketplace are the same as the current challenges for a marketplace. These are:

1. Customer service – how to service buyers and customers of your marketplace
2. Marketing the products and services– how to find buyers for the marketplace
3. Seller onboarding and management – how to attract the right sellers and products/services to your marketplace

This is where blockchain technology comes into its own – Trust, Transparency, and immutable data are all factors that will help solve these challenges.

- Trust, and the blockchain marketplace – trust in any transaction is critical, and with current marketplaces, you trust the corporate owner of the marketplace (Amazon, Alibaba, UBER etc.). Do the ratings on these marketplaces reflect the true satisfaction of buyers?

- Transparency and the blockchain marketplace – transparency of products/services quality and the ratings customers give are critical in a marketplace. Current marketplaces may or may not check the quality of the product/service, and you may find that the product is not what it was described. Often marketplaces will facilitate a refund, but this is difficult for a service and can cost more than just the price of the service. Is the product/service what it says it is?
- Immutable data and the blockchain marketplace – without Trust and Transparency, you cannot trust the data regarding your product or service – you must trust the centralized marketplace provider of the seller. With immutable data, all data and transactions are final, and the history is there for all to see – nobody can delete the bad feedback or the record of poor-quality products. Do you know if the data about your product or service is correct?
- Big data or “Value” and the blockchain marketplace – as users become more aware of current marketplaces who use and sell their data and analysis, a blockchain marketplace could allow users to each own their data, and choose where the data is used and for what. Users could even get “paid” to share their data to be given product and service offers from vendors, based on what data they choose to share about themselves. Who owns (profits from) MY data?

A blockchain-based marketplace will benefit significantly from these four factors, and all these factors (plus more) are benefits from implementing blockchain technology. If we get the first four issues correct, then you will see marketplaces that sell many different products and services succeed based on their use of blockchain.

**Feasibility of decentralised marketplaces**

This is probably a good point to look at the reality of decentralized marketplaces – and it is interesting to ask whether this is a dream, or in fact, a new business model reality. On the one hand, blockchain technology gives three beneficial factors to improve current marketplaces (Trust, Transparency and Immutability). On the other hand, there needs to be an agreed consensus or central point to deal with marketing, seller onboarding and customer service.

The idea of complete decentralization would not work with a marketplace. However, the benefits will still be achieved by implementing blockchain technology, and the parties involved can work on a consensus agreement for the “central” processes that need to happen.

*Example of a product marketplace: replacing Amazon, eBay or Alibaba*

Let us explore how a marketplace built on Blockchain technology would work – building a disruptive blockchain-based marketplace to take on Amazon, eBay, and Alibaba's current models.

The current model with most of these marketplaces:

1. Sellers list products onto the centralized system,
2. These items are then marketed by the centralized owner
3. Buyers buy the products either via auction or a fixed price
4. Delivery and logistics could be included

How would this work with a blockchain-based marketplace:

1. A group of entities/people need to form the blockchain marketplace team
2. The team need to agree the “rules”/principles around consensus, operations, customer service etc
3. There would need to be an investment in the marketing of the marketplace to both sellers and buyers

4. Sellers then list their products using the agreed consensus mechanism, to ensure the products are correct and verified
5. Buyers enter the marketplace and buy the product
6. Payment is made via a token or cryptocurrency (but doesn't necessarily have to be)
7. The seller dispatches the product, and the buyer confirms the arrival of the goods

This is very simple to write down, and the technology is a simple set up utilising blockchain and smart contracts. Add to this an agreed “centralized” consensus process to deal with the three significant challenges, and I believe you would have a very efficient and effective marketplace

The difference, and important benefit with a blockchain-based marketplace, would be more checking and vetting of the service provider at the start of the process. The marketplace will need to be sure that the service provider can provide the services offered to the specifications agreed. Smart contracts could be used to check certain information, and the use of customer feedback would be critical. This, again, could easily be automated via smart contracts, enabling bad feedback to be seen and actioned across the marketplace at speed.

**Decentralised marketplace case studies**

*Real use case: blockchain product marketplace: OpenBazaar*

OpenBazaar is a retail marketplace without fees or restrictions, powered by the cryptocurrency Bitcoin as a payment method. Individuals and businesses can trade with each other without any middleman or trusted third party involved.

The platform is a blockchain marketplace alternative for today's centralized services such as eBay, Amazon, and other platforms that usually charge fees for listing and selling products online.

- OpenBazaar connects people directly via a peer to peer network.
- Data is distributed across the network instead of storing it in a central database.
- OpenBazaar isn’t a company nor an organization; it’s free, open-source software.
- It was built to provide everyone with the ability to buy and sell freely.
- Nobody has control over OpenBazaar
- Each user contributes to the network equally
- Each user is in control of their store and private data

The store is very practical and not a great looking platform, from a customer experience point of view. Still, it is a great example of how a marketplace can be built and run successfully using blockchain technology.

*Real use case: blockchain Marketplace to replace UBER: EVA*

In 2018, I met the team behind EVA, which is a Canadian blockchain project positioned as the next generation of Uber. Eva offers a platform for direct interaction between drivers and passengers, to book rides and use the car-sharing service exactly like they would with UBER.

The application is based on blockchain technology, the core of which is the EOS blockchain. The company’s goal is to develop decentralized technologies for moving in the city.

The business model makes sense to me – in the current model, UBER retains around 30% commission from the drivers to pay for its service, marketing and fund the giant business that is UBER.

EVA aims to share that 30% in three ways:

1. Cheaper rides for the customer – who does not want to save money on car sharing?
2. More income for the driver – better-paid drivers, means happier drivers mean happier customers
3. Low costs to run the EVA business – because it is based on blockchain with no significant central costs

The team suggested they were already live in NYC and San Francisco – so let's see how they progress. This is one of many new marketplace blockchain companies that will start to disrupt the disruptors

*Other use cases: ModulTrade and Ink Protocol*

Small businesses often find that banks charge high fees to act as escrow, and that a letter-of-credit is often required. This means that small businesses often find their financial proposals rejected. ModulTrade solves this problem through smart contracts.

Ink Protocol is a decentralised reputation platform that allows the user to transfer their reputation between marketplaces.

These two platforms demonstrate some of the many capabilities of blockchain for the IoV and marketplaces.

**Conclusion**

When building a marketplace, there is a great opportunity to benefit from utilising blockchain technology. Trust, Transparency, and immutable data are key to a fully functioning decentralized marketplace.

The world of marketplaces are globally significant, and any new marketplace will have to beat the significant giants that exist today. I believe this can happen, and with blockchain technology as the enabler, we will see many more decentralised marketplaces.

# Part C: The IoV and the Circular Economy

*Geri Cupi*

## Introduction to the Circular Economy

The world's fast-growing population is impacting the environment, thus requiring changes in human behaviours. Sustainability is increasingly incorporated into both the agendas of policymakers and the strategies of companies. The term sustainability itself originates from the French verb soutenir, “to hold up or support” (Brown et al., 1987). Due to the Earth having finite resources, we need to ensure there is enough food, water and prosperity in the next decades. This can be solved by switching from the linear economy to a circular one.

In this Part we will explain what the Circular Economy is, why it is important and examine how the IoV can facilitate the circular economy.

### *A primer on the Circular Economy*

Our current economy is linear. This means that raw materials are used to make a product, and once this product is used, it is then thrown away (the raw materials fashioned into a product are not reused). This economic model has reached its limits, and a viable alternative is employing circular economy business models.

Since the late 1970s, the notion of the Circular Economy has been gaining popularity among scholars. Most scholars describe the circular economy by referring to the 3Rs: *Reducing* materials need and waste, *Reusing* products and *Recycling* materials (Kirchherr, Reike & Hekkert, 2017). This means that products and services are traded in closed loops or cycles. The goal is to develop an economy which is restorative and regenerative by intention and design. This maximises the value of products, parts and materials (Kraaijenhagen, Van Oppen & Bocken, 2016). Figure 4 illustrates the continuous flow of materials through the value circle.

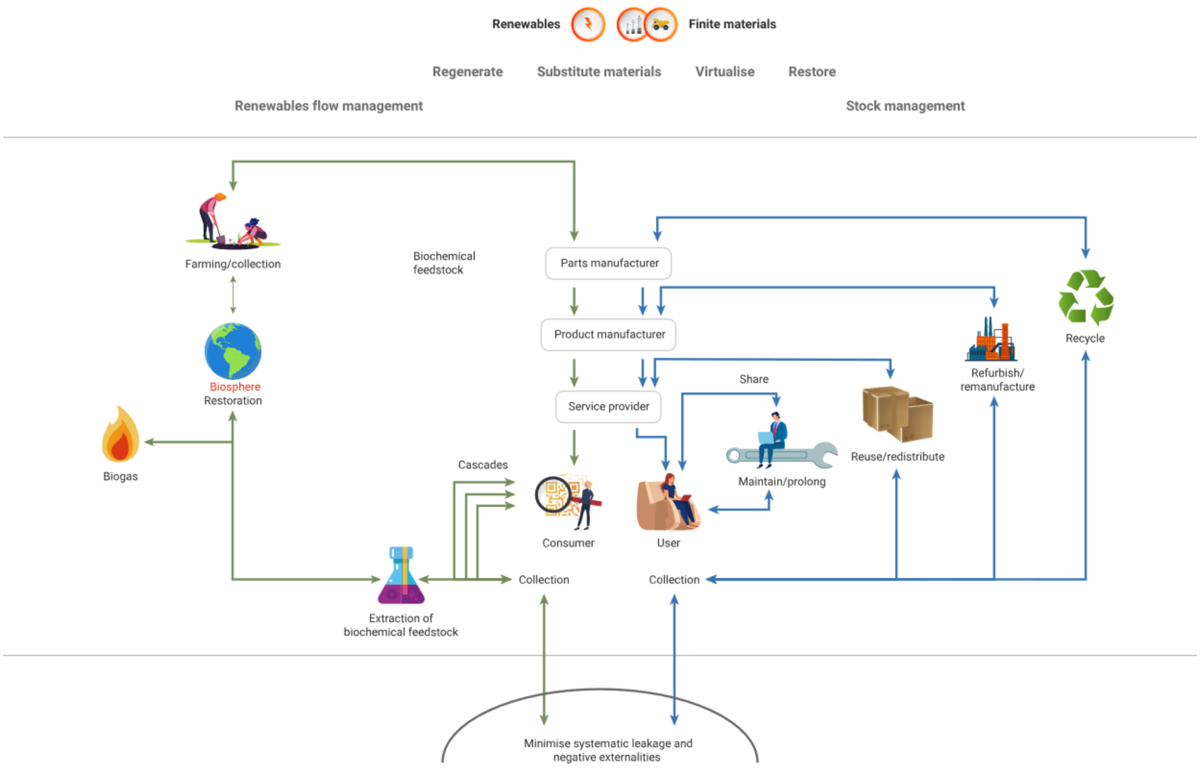


*Figure 4: Materials flow in a Circular Economy (Ellen MacArthur Foundation, 2016)*

Recently, the life of a product (and its usage) has decreased significantly, leading to the consumption of more goods. Consumers want new products fast and have been happy to discard old products. The linear economy has led to the creation of waste and stretched the limited resources of our world. As old products are discarded and disposed of, large amounts of resources are burned or left on landfills. The circular economy, as an alternative to the linear economy, can lead to many benefits such as economic growth, reduced pollution, greater employment and innovation incentives (Ellen MacArthur Foundation, 2015a).

The circular economy could boost Europe's resource productivity by 3% by 2030, generating cost savings of more than €600 billion a year and €1.8 trillion more in other economic benefits, according to McKinsey. Additionally, another 100,000 jobs could be created by 2025. The circular economy requires innovative solutions which reflect circular rather than linear value chains. This will result in interdisciplinary collaboration between designers, manufacturers and recyclers, leading to new insights and sustainable innovations (Kraaijenhagen, Van Oppen & Bocken, 2016).

$CO_2$ emissions could be reduced by 48% in 2030 and even 83% by 2050, according to the Ellen MacArthur Foundation, if circular economy business models are applied in the construction, food and mobility sectors. This would be by minimising fossil fuel usage, optimising usage scenarios for transport and eliminating fertilizer use (Ellen MacArthur Foundation, 2015b).

*How the IoV can help*

To move from a 'throw-away' society to a one that that looks at waste as a valuable resource, we need to reduce, reuse, and recycle.

**The Three Pillars of the Circular Economy**

*Reduce*

Consumption can be reduced through sustainable production and by helping customers take more considered action (including reducing the production of counterfeited items).

Transparency and traceability are becoming an important (and in some cases legal) requirement. DLT enables the provenance of an item. This can become beneficial in several ways. One benefit is with counterfeiting. Counterfeiting is worth nearly 0.5 trillion dollars according to the OECD (2016). A large proportion of this is deceptive counterfeiting (where customers get tricked into buying a fake item). As well as economic loss, many human lives are also lost as a result of this every year (Hirschler, 2017). Customers can make better informed decisions if an items provenance is known reducing usage of counterfeit items.

Another benefit is on the validity of assurances on respecting human rights and fair work practices. For example, provenance assures buyers that the item being purchased is supplied and manufactured from sources that are ethically sound.

There is also benefit in discarding wasted material from the manufacture of goods. In almost every industry, production leads to wasted material. For example, in construction, this is around 10-15% according to McKinsey. In the fashion industry, the term is deadstock, and its value is over 100 billion dollars per annum. All this waste goes to landfills. There are solutions of marketplaces using blockchain for this excess material to be traded between producers.

*Reuse*

Blockchain can be used to enable the reuse of items. Solutions like MonoChain[27] providing a certificate of ownership that can enable luxury items to be resold as their life cycle and ownership can be tracked. Owners can also be incentivised to use a product or service longer through financial incentives. One way this can work is that the more they use a product or service more they get rewarded through tokens.

*Recycle*

Blockchain can also be used to improve recycling. Millions of dollars are spent every year by recycling companies to manually inspect item labels of goods sent for recycling to make sure that non-recyclable materials are discarded (in case they are toxic). By having better provenance and tracking of items on through the IoV, these costs can be reduced massively, and a large amount of time saved. Financial incentives might also be used to motivate people and organisations to recycle more. For instance, when returning cans or bottles to be recycled, consumers can get rewarded through tokens.

**Circular Economy for the Fashion Industry**

[27] Monochain - https://www.monochain.org/

The fashion industry is one of the most resource-intensive industries. The carbon footprint of 1 tonne of clothes generates approximately 23.2 tonnes of CO2e, consumes 7,060 m3 of water and produces 1.7 tonnes of waste annually (WRAP, 2017). The problem does not stop there as 80% of fashion's waste is either incinerated or landfilled with major negative environmental implications like soil acidification. Plus the widespread use of synthetic textiles releases microplastics into our oceans (Ellen McArthur Foundation). That is why the industry also accounts for 8.1% of global climate impacts across non-renewable energy use, freshwater use, human health, GHG emissions and ecosystem pollution (Quantis, 2018). In the UK, it is the fourth most impactful after construction, transport and food (WRAP, 2017). Yet, its negative impact is expected to even exacerbate in the future with GHG emissions and waste, both expected to increase by about 60% until 2030 to around 2.8 billion and 147 million tons/year respectively (Global Fashion Agenda and the Boston Consulting Group, 2017).

There are approximately 21 billion tons of textiles sent to landfill every year. The fashion industry's CO2 emissions are projected to increase by more than 60% to nearly 2.8 billion tons per year by 2030 - equivalent to almost 230 million passenger vehicles driven for a year, assuming average driving patterns.

By having multiple-owners of each clothing item, the need for buying new clothes decreases and you don't waste clothing life-cycles. Research by Ipsos MORI has shown that more than half of us own unworn clothing that no longer fits, 10% hang on to worn out favourites, and 36% own items that they consider have gone out of fashion. For instance, increasing second-hand sales by 10% would decrease the UK's carbon footprint by 3%, water footprint by 4% and waste footprint by 1%, per tonne of clothing (WRAP, 2017). As the extent of waste in the fashion industry increases in prominence, it will become clear that the circular economy offers a potential solution, meaning that the provenance of the product becomes critical.

One of the megatrends in the industry is the secondary market, which was valued at $24 billion in 2018 and is expected to grow nearly 1.5 times the size of fast fashion within the next ten years. The interest in secondary fashion comes from both sides as 72% of second-hand shoppers shifted away from traditional retailers to buy more used items and 90% of senior retail executives showing interest in the resale market to advance their company's circular fashion efforts by 2020 (Global Fashion Agenda and the Boston Consulting Group, 2017; ThredUp, 2019)

**MonoChain as an example of a Circular Economy fashion company**

MonoChain makes the reuse process much easier and more attractive for customers due to a simple, but informative and appealing online interface that enables customers to sell items in less than ten seconds. This support the growing and important secondary market for fashion items.

MonoChain offers a ledger based on blockchain technology that shows who owns what, who is an authorized licensee, and enables everyone in the supply chain, including consumers and customs authorities, to validate a genuine product and distinguish it from a fake. MonoChain allows for provenance authentication since verifiable details can be recorded objectively about when and where products are made, and raw materials used.

Fashion companies have the opportunity of extending their relationship with the customer and monetization of the product well beyond current limits by providing a value-added service of reducing the risk of being caught out by counterfeit fraud and facilitating opportunities to re-sell the product at the end of its life with a particular customer.

MonoChain is a B2B partner for global fashion companies, providing them with the opportunity to extend relationships with their customers (and – vitally their lifetime value). Specifically, MonoChain can transform the secondary market but allowing firms to facilitate the onward sale of fashion items.

How does MonoChain work now - every time a user buys an item, he/she receives his/her Certificate of Ownership, a Non-Fungible Token (NFT). The user has the opportunity to enter it into their MonoChain wallet. When that is done, the user can receive offers to sell the item in real-time. If user 1 (Seller) decides to sell this item to user 2 (Buyer), the item is sent to a Moderator for verification first. A Ricardian Contract using a Multisig Escrow is used, and this means that the NFT and money will be held in separate wallets. If the Moderator verifies the item is authentic, the NFT and the product move to the Buyer and the Seller receives the money. Every time ownership changes this will be recorded into a private blockchain (Hyperledger Sawtooth), but eventually, Monochain plans to move into a public blockchain and in the future include information on the item's provenance, materials and so on.

The Monochain solution will have a great sustainability impact. Firstly, it will lead to an increase in the ability to track the source of materials to be used in production (e.g. provide traceability). Secondly, it will increase the utilization rate and decrease the risk of throwing away clothes after minimal use. Thirdly, it will enable easier recycling and automated sorting of clothing based on textile components (e.g. easier to separate polyester clothes from cotton clothes).

MonoChain facilitates selling and buying second-hand items. For sellers, they know that they can get a price premium on items that have been proven as authentic, so they are incentivised to sell.

**Non-Fungible Tokens**

Blockchain in the context of the IoV goes beyond cryptocurrency. NFT represent an important tool to secure uniqueness and identity. NFT enable certificates, real estate data, physical assets, and people's identities to be added on the blockchain.

Fungible refers to goods which are interchangeable or equivalent to other units of the same commodity. A fungible good has no uniqueness and is perfectly interchangeable with another unit. Only the number of units (quantity) is important for fungible goods. If two people swap a tangible asset, they don't lose or gain anything as far as it is the same quantity. Fungibility is a very important attribute for any currency. Fungible tokens include the likes of Bitcoin, Ether, EOS, XRP or any type of ERC20 tokens. If you send someone 10 Ether, and get ten back, you will not be better or worse off.

NFTs, on the other hand, are unique and different from one another despite sharing common attributes. NFTs can standardise ownership of a certain asset category, but those assets don't necessarily have the same market value. Examples include collectables such as baseball cards, autographed football shirts, your identity, tickets and diplomas.

Table 7 shows some of the differences between fungible and non-fungible tokens.

| Fungible Tokens | Non-Fungible Tokens |
|---|---|
| **<u>Interchangeable</u>**<br><br>A token can be exchanged for any other token of the same type and keep the same value. A 1 USD bill can be exchanged with another 1 USD bill without any difference to the holder. | **<u>Non-Interchangeable</u>**<br><br>NFTs cannot be replaced with other NFTs of the same type and keep the same value. If you lend a token to someone, you would expect to receive the same token back. You cannot exchange your driving license with the driving license of another person. |
| **<u>Identical</u>**<br><br>All tokens are the same and have the same specifications. | **<u>Unique</u>**<br><br>Each token has unique attributes and different from tokens of the same class. This makes them irreplaceable or impossible to swap. |
| **<u>Divisible</u>**<br><br>Tokens can be divided into smaller units, and the unit you get it is not important as far as it has the same value. For example, changing USD bills with coins. | **<u>Non-Divisible</u>**<br><br>NFTs cannot be divided into smaller units as the NFT is the elementary unit and one token only. |
| **<u>Ethereum Standard used: ERC-20</u>**<br><br>This standard on the Ethereum Blockchain allows the issuance of tokens | **<u>Ethereum Standard used ERC-721</u>**<br><br>This is a new (2017) standard on the Ethereum Blockchain which enables the issuance of NFT. |

*Table 7: Differences between fungible and non-fungible tokens*

However, until recently, there were no standards for NFTs. This changed with the launch of ERC 721 in late 2017. This standard allows for the creation of NFTs on Ethereum and opened up the possibilities for digital collectibles.

One of the key features of NFTs is the ability to create digital scarcity which can be verified without needing or trusting a central authority to confirm this authenticity. The amount of NFT on Blockchain is visible to everyone. In the past, there have been attempts to offer and manage scarce digital items such as avatars in Warcraft or other games. However, this scarcity was not cheap to manage and depended on the validation and security of game creators. In the real-world, companies try to keep their products scarce by limiting the number of hours they sell their products. Cryptokitties are a good example of how a token can be used to create scarcity and therefore, value for a digital asset. With ERC-721, both the uniqueness and scarcity of an item is provable.

*<u>NFT example: Cryptokitties</u>*

Cryptokitties[28] are an example of NFTs on Ethereum. Cryptokitties took the blockchain world by storm in 2017. CryptoKitties are collectable assets, which are unique and stored in Ethereum wallets. People can buy, sell and breed digital cats (each cat's digital genetic material being stored on the blockchain). At the height of interest in Cryptokitties, some kitties were selling for $300,000, and the number of

[28] Cryptokitties - https://www.cryptokitties.co/

transactions slowed down the entire Ethereum network. In 2017, their sales hit over $12M, just three months after their launch.

*General use cases*

As well as Cryptokitties, there is a wide range of use cases for NFTs. These can be found in table 8.

| Use Case | Description |
|---|---|
| Video gaming | NFTs can be used to buy and sell digital world items (used in computer games). An example of this is Decentraland[29] |
| Collectables | Pokemon cards, baseball cards, stamps, autographed football shirts or any other collectable one can imagine can have their digital counterparts collected and tracked. An example of this is Opensea[30] |
| Fashion | Luxury fashion items can have their provenance proven and successfully support a vibrant secondary market. Aura (Consensys, 2019), Arianee[31] and Monochain are providing tracking services for fashion items. |
| Tickets | NFTs also find another use in the tickets industry. Every ticket has its own NFT and given to the buyer. Upgraded[32] is a company which does exactly this and recently was acquired by Ticketmaster. The GET Protocol[33] also support ticketing solutions on a blockchain. |
| Art | Art is another industry that is a target of forgery, scams and frauds. NFTs can tack ownership on a system, which cannot be altered or falsified. Companies working on this space are Verisart[34] and Artory[35]. |
| Identity | Every person has their characteristics which can be represented by an NFT. There can be NFT for your passport, driving license or ID. This cannot be traded but can be used to interact with authorities or share this information voluntarily with whoever needs your proof of identity. Examples include Sovrin[36] and uPort[37]. |
| Academic Credentials | Various academic institutions have used blockchain technology to place academic credentials online, including UCL and the University of Nicosia. |
| Licensing | Software licensing is another usage of NFTs. This can reduce piracy and allows people to trade their software licenses. Users can potentially avoid yearly subscriptions when not required anymore. The license can turn into an asset for the user. An example of this is license.rocks[38] |
| Real Estate | Another use case is in the real estate industry where a building can be tokenised. Some tokens can grant ownership of the building and facilities, while others enable access. Examples include Meridio[39] and Real Blocks[40] |

*Table 8: General use cases for NFTs*

## Conclusion

[29] Decentraland - https://market.decentraland.org/
[30] Opensea - https://opensea.io/
[31] Arianee - https://www.arianee.org/
[32] Upgraded - https://www.upgraded-inc.com/
[33] GET Protocol - https://get-protocol.io/
[34] Verisart - https://verisart.com/
[35] Artory - https://www.artory.com/
[36] Sovrin - https://sovrin.org/
[37] uPort - https://www.uport.me/
[38] license.rocks - https://license.rocks/
[39] Meridio - https://www.meridio.co/
[40] Real Blocks - https://www.realblocks.com/

Circular economy business models can be empowered through the IoV and with NFTs. The IoV gives the opportunity to tokenise real-world goods, which can be much more fruitful from not only an investment but also an access perspective. New business models can not only help to satisfy important sustainability goals but can also empower consumers in a way not seen before. NFTs can be the backbone of a new blockchain-powered economy on the IoV.

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# Chapter 6: The IoV and Internet of Things

*Rajan Kashyap*

The number of Internet of Things (IoT) endpoints are expected to reach an installed base of 25.1 billion units by 2021, having experienced a 32% growth rate over the preceding five years (Gartner, 2017). As ever more devices become connected, IoT devices are becoming a daily and soon integral part of our lives. This boon in devices all connected can enable brand new business models to be developed.

As IoT becomes more prevalent, the scope for security and scalability issues increases. This is where the overlap with blockchain comes in as blockchain can be utilised in order to alleviate some of these issues. IoT combined with blockchain, and smart contracts can unlock several new opportunities for value creation and capture.

This chapter has been written by UCL CBT Industry Associate Rajan Kashyap, who focuses on discussing new business models that can emerge from the IoV. Using the Business Model Canvas, different types of emerging business models powered by IoT and the IoV are discussed, including Customer to Customer, Customer to Machine and Machine to Machine. Some use cases of IoT and blockchain follow, and finally, the chapter finishes with a brief analysis of how IoT is intertwining with other emerging technologies, including AI and 5G.

Feedback for this chapter was provided by Stylianos Kampakis.

**Internet of Things and related business models**

The Internet of Things (IoT) is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction (Wikipedia Contributors, 2019).

With IoT came the proliferation of sensors for light, sound, vibration and temperature; sensors for everything that one could imagine. The data from these sensors became extremely helpful in tracking, measuring, controlling, and monitoring remotely. This capability led to the introduction of many new business models and innovation in existing business models. Some of the prominent IoT based business models are (Chaabane, 2017):

- **Product as a service**: the customer does not buy the product, but rent/leases it from either the manufacturer or a third party. The responsibility of maintaining the equipment lies with the equipment owner (i.e. the manufacturer or the mediator). IoT played a big role in this model as the remote monitoring of equipment became simple and acceptance of this model increased. The Healthcare industry is a big adopter of this model as healthcare equipment is expensive and needs pro-active maintenance.
- **Performance-as-a-product:** the ownership of equipment is necessary or desired, but the performance of the machine can still be outsourced with this model. For example, the cost of maintenance of jet engines in aircraft can be extremely expensive and might have a large impact on the business. In such a case, the business owner would like the experts (manufacturers) to be responsible for the performance of the machine. Most jet engine manufacturers offer some sort of care package where they will be guaranteeing the performance of the engine by remotely managing and monitoring the engine and performing maintenance.

IoT has also enabled a variety of new ways to do business and has found a good niche in the Sharing Economy with the following applications:

- **Revenue Sharing:** through new services provided to end-customers**.** One such example is bag tracking services provided by airlines. A passenger's bag will be tagged with a sensor provided by an airline partner, and this service can be purchased for an additional fee. The revenue generated is shared between the airline and the tag provider.
- **Cost-saving Sharing:** it is hard for businesses or individuals to keep tracking the usage of a commodity. In this model, a third party can monitor and regulate the usage with the help of IoT sensors and help save on costs of usage. The savings are shared between the business/individual and the service provider.
- **Product/Asset Sharing:** where a big asset like a car can be shared among multiple users who only pay for the usage of the asset. This model is very similar to the product as a service model, but in this case, the asset is used by multiple users.

**Inefficiencies in current IoT business models**

Almost all business models that depend on IoT have significant inefficiencies leading to a higher cost to the consumer/end-user. The primary reason for these inadequacies is the presence of a human intermediary. While the intermediaries are an overhead, they are necessary to ensure the privacy, integrity and trust in the transactions.

The presence of intermediaries leads to the unwillingness of the consumer to share sensitive data (e.g. personal health data). While IoT sensors can collect a wide variety of data, the availability of that data to unlock its full potential is very limited. Even though current IoT business models are successful, there is significant value yet to be unlocked.

**<u>How the IoV and Blockchain can help</u>**

Blockchain technology is the missing link enabling peer-to-peer contractual behaviour without any third party to "certify" IoT transactions. It answers the challenges of scalability, single point of failure, time stamping, record, privacy, trust and reliability in a very consistent way (Satish143, 2017).

Blockchain/DLT can ensure integrity and privacy without the need for any intermediary. The technology can bring trust in a system, encouraging people to share sensitive information as well as enable two machines to work together and fully trust the data as it is written on a tamper-proof ledger. This can enable unhindered transactions across the ecosystem without ever being mediated by a third party, which can result in various new business models.

The Blockchain-IoT integration approach opens the doors for countless new opportunities, such as (Alam, 2019):

- **Building Trust:** among the various connected devices because of its security features; only verified devices can communicate in the network and every block of the transaction will first be verified by miners and then can enter the blockchain.
- **Savings in Costs and Time**: this approach will reduce the cost because it communicates directly eliminating all the third-party nodes between the sender and the receiver. It provides direct communication, thus reducing the time taken in transactions from days to seconds.
- **Security and Privacy:** by facilitating secure access to data. Blockchains are not designed to store large amounts of data, but they can provide "control points" to monitor data access. [5]
- **Creating the right incentive structure**: to share IoT/cross-sectional data which can have the most disruptive impact across different industries. Blockchain (and tokenisation) can be used to solve the "how and why sharing data" dilemma. Once data is shared, it can be more easily validated, authenticated and secured (Corea, 2018).

**<u>The IoT/Blockchain Business Model Canvas and industry applications.</u>**

Osterwalder and Pigneur (2010) proposed the "Business Model Canvas" providing nine building blocks. This is shown in figure 5.

**Business Model Canvas**

<table>
<tr>
<td rowspan="2">Key Partners<br>Who are your key partners?<br>Who are your key suppliers?<br>Which key resources are we acquiring from our key partners?<br>Which key activities do our key partners perform?</td>
<td>Key Activities<br>Which key activities do our value propositions require?<br>Our distribution channels?<br>Customer relationships?<br>Revenue streams?</td>
<td rowspan="2">Value Proposition<br>What value do we deliver to our customers?<br>Which of our cusotomer's problems are we helping to solve?<br>What bundles of products and services are we offering to each customer segment?<br>Which customer needs are we satisfying?</td>
<td>Customer Relationships<br>Which type of relationship does each of our customer segments expect us to establish and maintain with them?<br>Which ones have we established?<br>How are they integrated with the rest of our business model?<br>How costly are they?</td>
<td rowspan="2">Customer Segments<br>For whom are we creating value?<br>Who are our most important customers?</td>
</tr>
<tr>
<td>Key Resources<br>What key resources do our value propositions require?<br>Our distribution channels?<br>Customer relationships?<br>Revenue streams?</td>
<td>Channels<br>Through which channels do our customers want to be reached?<br>How are we reaching them now?<br>How are our channels integrated?<br>Which ones work best?<br>Which ones are most cost efficient?<br>How are they integrating them with customer routines?</td>
</tr>
<tr>
<td colspan="2">Cost Structure<br>What are the most important costs inherent to our business model?<br>Which key resources are the most expensive?<br>Which key activities are the most expensive?</td>
<td colspan="3">Revenue Streams<br>For what value are our customer really willing to pay?<br>For what do they currently pay?<br>How are they currently paying?<br>How much would they prefer to pay?<br>How much does each revenue stream contribute to overall revenues?</td>
</tr>
</table>

*Figure 5: Business Model Canvas: nine business model building blocks (Osterwalder & Pigneur, 2010)*

Based on work by Liu (2018), three different general business models for IoT-Blockchain and their application to key industries can be created (using the Business Model Canvas) that could showcase how these industries could be disrupted by new business models.

1) **C2C (Customer to Customer):** This model can enable transactions between two customers directly without the need of a third party as trust is established by the network. For example, the owner of a self-driving car can earn extra money by renting it out to anyone who needs it. Normally, the owner of the vehicle is not sure about the renter's driving capabilities and does not trust the other person. However, in the case of self-driving cars applied to a blockchain-based solution the owner of the vehicle can be far more confident about renting the car to a stranger as there is an existing shared record of his driving performance. This is shown in figure 6.

**Business Model Canvas - C2C - Self Driving Cars**

| Key Partners | Key Activities | Value Proposition | Customer Relationships | Customer Segments |
|---|---|---|---|---|
| Self Driving Car Companies<br>Blockchain Platform<br>Investors<br>Self-driving car owners | Dapp Development<br>Maintenance and updates | Cash Free Taxi Service<br>Secured Transaction Record<br>Chance to earn additional money with spare resources<br>Wider Scope of digital currency<br>New method to freelance | Automated service<br>Co-create Value | Self-Driving Car Owners<br>Passengers |
| | **Key Resources** | | **Channels** | |
| | Venture Capital<br>Software R&D | | Dapp<br>Social Media Marketing | |

| Cost Structure | Revenue Streams |
|---|---|
| Software Development<br>Salaries<br>Marketing | Advertisement<br>Value-added Services<br>Acquisition |

*Figure 6: C2C (Customer to Customer) Business Model Canvas*

2) **C2M (Consumer to Machine)**: Customers can interact directly with machines and upgrade their features with digital payments. This is shown in figure 7.

**Business Model Canvas - C2M - Upgrade the equipment**

| Key Partners | Key Activities | Value Proposition | Customer Relationships | Customer Segments |
|---|---|---|---|---|
| Equipment Manufacturer<br>Blockchain Platform<br>Digital Payments provider<br>Customer | Pluggable Feature Development<br>Payment processing | Incremental revenue for Manufacturer<br>Pay-as-you-go upgrades for customer | Automated service<br>Co-create Value | Equipment owners<br>Third party providers |
| | **Key Resources** | | **Channels** | |
| | Software R&D | | Equipment interface | |

| Cost Structure | Revenue Streams |
|---|---|
| Feature Development<br>Marketing | Value-added Services |

*Figure 7: C2M (Consumer to Machine) Business Model Canvas*

3) **M2M (Machine to Machine):** Machines talking to each other can reduce supply chain delays and create revenue for the manufactures/producers. For example, the truck in the yard can talk to warehouse autonomous fork-lifts about its presence on the loading gate. All the interfaces on the supply chain can be automated using a machine-to-machine interface. This can be seen in figure 8.

**Business Model Canvas - M2M - Automated Supply Chain**

| Key Partners | Key Activities | Value Proposition | Customer Relationships | Customer Segments |
|---|---|---|---|---|
| Equipment Manufacturer<br>Blockchain Platform<br>Digital Payments provider | Machine to machine interaction development<br>Payment processing | Incremental revenue<br>Increased process efficiency | Automated service<br>Co-create Value | Equipment owners<br>Third party providers |
| | **Key Resources** | | **Channels** | |
| | Software R&D | | Equipment to equipment interaction | |

| Cost Structure | Revenue Streams |
|---|---|
| Feature Development<br>Marketing | Value-added Services |

*Figure 8: M2M (Machine to Machine) Business Model Canvas*

With these three Canvas/Models, we can look at how these can be applied to specific industries, in table 9, where the examples tell us more about what model fits what business and what the main dynamics are.

| **Industry** | **Application/product** | **Model** |
|---|---|---|
| **Automotive** | Pre-paid direct hire of autonomous vehicle<br>Self-parking and Automatic updates<br>On-Demand features upgrade | C2M, C2C, M2M |
| **Healthcare** | Personal Medical records monetization<br>Personalized Pre-emptive healthcare services | C2M, C2C |
| **Retail** | P2P transactions without any intermediary like eBay | C2C |
| **Logistics** | Consumer to machine interaction | C2M, M2M |
| **Smart Homes** | Lifestyle data monetization<br>Automatic product ordering and payments | C2M, C2C, M2M |
| **Insurance** | Pre-usage based insurance<br>Automatic claims settlement<br>Personalized medical insurance plans | M2M, C2M |
| **Manufacturing** | Personalized manufacturing | M2M |

*Table 9: Models applied to specific industries*

**Blockchain projects utilising IoT**

Many blockchain projects are utilising IoT to facilitate business processes in nearly every sector imaginable. In this section, we will look at a few examples of companies utilising blockchain and IoT and with what use cases.

IOTA is one example of a cryptocurrency for the IoT industry. The main feature is the tangle, a DAG for storing transactions (Popov, 2018). The tangle can be considered the next evolutionary step of the blockchain, offering features that are required to establish a machine-to-machine micropayment system. Other authors in this report elucidate on the tangle (see Chapter 1) consensus mechanism.

IOTA states that its technology is being used in several different areas including mobility and automotive, global trade and supply chains, industrial IoT, EHealth, Smart Cities, Customs and Border Management and Digital Identity. Let us look at a few of these in more detail and see how IoT is enabled with IOTA.

Within the Smart Cities area, IOTA could be used in order to gather information from IoT sensors from people and objects within the city. This could then be reported to both residents and authorities. IOTA is involved in Project Alvarium (Yarger, 2019) alongside Dell Technologies and the Linux Foundation. This project is creating an open-source technology stack with multiple stakeholders working together and enabling large scale complex integrations. This can form the technology stack that systems in smart cities are built on top of. Within the eHealth arena, IOTA has been used by SmartOptz, allowing patients to monitor their own healthcare data and share it with others (SmartOptz PLT. n.d.). IOTA has also been used by Pact[41] to facilitate the sharing of healthcare data among institutions and patients via an API that interfaces with the Tangle. Finally looking at the Mobility and Automotive industry, IOTA is being utilised by Jaguar and Land Rover where cars are being created with built-in wallets enabling them to make and receive payments for selling data, paying for parking and tolls.

As well as IOTA, there are several other projects that utilise blockchain and IoT. Modum[42] is a blockchain company that is creating trusted digital ecosystems for sensitive goods and digitalising supply chains. With reference to IoT, Modum produces MODsense devices that can be used to track items in a supply chain that interface with their blockchain solutions. The MODsense One device monitors temperature and is particularly suitable for pharmaceutical supply chains (modum.io AG, n.d.).

OriginTrail[43] is another example of a blockchain company that is creating an ecosystem dedicated to making global supply chains come together. One particular use case for IoT devices is in Smart Farming. Here, OriginTrail is protecting data from Kakaxi's[44] IoT farming devices, fostering consumer trust in the provenance of their food. Kakaxi's IoT devices integrate cameras and climate-monitoring devices, collecting data such as temperature, humidity, day-length and rainfall (OriginTrail, n.d.).

**From IBM Watson to AWS IoT**

From theory to reality, we see the blend of IoT and AI already serving the world through major corporations which are leading the next generation IoT solutions. Namely, IBM Watson and Amazon IoT.

The IBM Watson IoT Platform is a foundational cloud offering that can connect and control IoT sensors, appliances, homes, and industries. Built on IBM Cloud, the Watson IoT Platform provides an extensive set of built-in and add-on tools. These tools can be used to process IoT data with real-time and historical analytics, extract key performance indicators (KPIs) from data, add "smarts" in the cloud for non-smart products, and securely connect apps and existing tools to the Watson IoT Platform infrastructure (IBM Corporation, n.d.).

AWS IoT Core is a platform that enables one to connect devices to AWS Services and other devices, secure data and interactions, process and act upon device data, enables applications to interact with devices even when they are offline, and that allows one to produce low-cost Alexa built-in devices (Amazon, n.d.).

**A final remark on AI and 5G**

**5G:** Low-latency is one of the key requirements of most of the use cases with IoT. Current 4G networks are unable to cope with the volume and speed needed for these use cases to work. Consequently, IoT implementation is limited within controlled environments barring a few implementations like autonomous cars. 5G is expected to provide a network speed of 100gbps, which is almost 20 times faster than 4G networks. The upgraded speed and capacity will enable use cases that are currently not prevalent.

[41] PACT Care BV - https://pact.care/
[42] Modum.io AG - https://modum.io/
[43] OriginTrail - https://origintrail.io/
[44] KAKAXI, Inc - https://kakaxi.me/

**AI or Artificial Intelligence**: M2M communication is increasingly going to be independent of any intervention, requiring machines to become intelligent. Artificial intelligence will play a key role in machine decision making.

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# Chapter 7: IoV and Systemic Risk

Systemic risk refers to the risk of a failure of an entire system as opposed to the malfunction of individual parts. Certainly, systemic risk increases with the number of interdependencies between numerous and diverse networks of trust, which characterise the IoV. This may create a high level of network interdependency. We do not have data to measure the systemic risk on the IoV because it is still in its infancy. However, we can learn from other interconnected systems like the financial system, and we can derive some properties that can be used as a reference to measure the potential risks emerging on the IoV. History teaches us that increasing interconnection in complex financial systems is characterised by emergent properties that are not observable at the micro-level, and higher fragility that can lead to cascading defaults and failures. Networks exhibit a trade-off between efficiency and robustness to attacks. The network topology, which is desirable for efficiency gains, does not generally match the one that is preferable in terms of robustness against attacks.

This Chapter focuses on the emerging systemic risks associated with the IoV. Part A is written by Fabio Caccioli and focuses on the structure, robustness and efficiency of networked systems. Part B is written by Josep Lluis de la Rosa Esteva and discusses risks focussed on the IoV.

Navroop Sahdev supported the creation of this Chapter, and feedback was provided by Paolo Tasca.

## Part A: Structure, Robustness and Efficiency of Networked Systems

*Fabio Caccioli*

### Introduction

The development of blockchain and distributed ledger technologies aims to transform economic interactions by facilitating the way value is stored and transferred between individuals. This is achieved through the emergence of peer-to-peer systems, where users directly interact with one another rather than through intermediaries, thus reducing the cost associated with their transactions.

Users will contribute to the development and maintenance of such platforms, which should, therefore, emerge with no need for central planning, apart from the set-up of some engagement rules that define the collective decision-making process.

Such engagement rules must provide the right structure of incentives for the system to correctly develop as a distributed system where all users are equal. This is non-trivial, as networked systems that develop over time in a self-organised manner with no central planning tend to become more centralised and display the existence of special users on which interactions tend to concentrate.

The emergence of special users occurs because of a simple self-reinforcing mechanism: If a user is more important than others, other users will tend to interact with that user, thus making it more important (Yule, 1925; Simon, 1955; Price, 1976; Barabási and Albert, 1999).

From the point of view of the system as a whole, there are benefits and risks associated with the emergence of special users: Their existence can facilitate the propagation of information and overall efficiency of the system. This, however, comes at the expenses of increased fragility of the system to attacks targeted to the special users. This implies the existence of trade-offs between efficiency and robustness that one needs to account for when designing a networked system.

The study of networks, a very active field of research in complexity science since the 90's, provides useful insight concerning these mechanisms and trade-offs. Here we will review - in an idiosyncratic manner and without claim to completeness - some lessons that have been learned in relation to the stability and efficiency of complex networks and we will try to derive some insights for IoV networks. The interested reader can refer to the following references for comprehensive reviews on complex networks (Albert and Barabási, 2002; Caldarelli, 2007; Barrat et al., 2008; Dorogovtsev et al., 2008; Newman, 2010).

### Random networks

Networks are a mathematical abstraction used to represent systems composed by many units that interact in pairs. The mathematical representation of a network is given in terms of a set of nodes (representing the units) and links that connect nodes (representing interactions).

The typical question that one asks when studying a network is that of the relation between the structure of the network and its function. One would like to find general relationships that are independent on the fine-grained details of the network at hand, in order to draw conclusions that are valid for a class of networks rather than a specific realisation, which may, for instance, be affected by noise. To this end, different classes of random networks have been introduced in the literature (Albert and Barabási, 2002; Caldarelli, 2007; Barrat et al., 2008; Dorogovtsev et al., 2008; Newman, 2010). For each class, some specific features are (statistically) fixed, the rest being as random as possible. This allows us to understand the effect on the system of those features that are being determined.

The most famous class of random networks are Erdös-Rényi networks Erdös-Rényi (1959). An Erdös-Rényi network with N nodes can be constructed by considering all possible pairs of nodes and drawing a link between each pair with probability p. The parameter p controls the level of connectivity of the network: each node will on average be connected to $\langle k \rangle = p(N - 1)$ other nodes. The number of neighbours of a node is called its degree. A network's degree distribution is the distribution of degrees across its nodes. We will see in the following that the degree distribution strongly affects the property of random networks.

In the limit of large networks ($N >> 1$) the degree distribution of Erdös-Rényi random networks is a Poisson distribution with average $\langle k \rangle$. For this type of distribution, the probability of observing a node with degree much far from the average degree decays quickly, so that Erdös-Rényi networks are typically used to describe systems where all nodes have similar connectivity.

Also, in a regular lattice (like for instance a 2-dimensional grid) nodes have similar connectivities (in fact they have the same degree). Erdös-Rényi networks are however quite different from a regular lattice because the average distance between nodes is much smaller: In a regular d-dimensional lattice, the average distance between nodes grows as $N^d$ , while on Erdös-Rényi networks it grows only as log N. This means that Erdös-Rényi networks, at odds with regular lattices, are quite compact objects: it is possible to navigate between nodes quickly, and this remains true as we increase the size of the network.

Because random networks appear to be easy to navigate, and because all nodes of an Erdös-Rényi network have similar importance (when measured in terms of connectivity), we can consider Erdös-Rényi networks as prototypical examples of distributed networks.

While very useful from a theoretical point of view, the analysis of many real networked systems (technological, biological, social) made it clear that Erdös-Rényi networks are however not a good model to describe the connectivity of real networks. The latter tend in fact to be characterised by heterogeneous distributions of degrees, with a few nodes acting as highly connected hubs among a majority of less connected nodes. There are many more differences between real networks and random networks, we focus here, however, for simplicity on the degree distribution, as this can be linked to the centralisation of the network.

The configuration model is a way to generalise Erdös-Rényi networks to networks with any degree distribution. Rather than just fixing the average degree as in Erdös-Rényi networks, we now fix the entire degree distribution P(k). A network of the configuration model can be generated as follows: First, we assign to each node i several half links $k_i$ drawn from the probability distribution P(k). Then we randomly match half links to form links between pairs of nodes. In this way, it is possible to generate networks with any given degree of distribution.

To mimic the connectivity pattern of real networks, the class of scale-free random networks has, in particular been considered in the literature (Albert and Barabási, 2002). These networks are characterised by a power-law distribution of degrees $P(k) \sim k^{-\gamma}$. When the exponent γ satisfies $2 < \gamma \leq 3$, the variance of the degree distribution diverges, which makes it apparent that the fluctuations of degrees across nodes are large. The existence of hubs in scale-free networks facilitates the navigability of the network, as they can act as shortcuts to move from one node to another. In fact, the typical distance between nodes in such networks scales as log(log N) (Cohen and Havlin, 2003), even more slowly than for Erdös-Rényi networks.

Given the inequality in terms of nodes' degrees that characterises scale-free networks, we will consider them in the following as examples of effectively centralised systems (a purely centralised system would be represented by a star network, with the provider of the service at the centre, and all users connected to it. In a scale-free network, there is no single central node, yet most of the activity is concentrated on a few nodes).

**Large-scale connectivity of random networks**

Intuitively, we would expect a networked system to be able to perform its function if it is "well connected", that is if it is possible to reach a sizable fraction of nodes from any other node. This is, for instance, the case if the network is supposed to enable the transfer of information between its parts.

This intuition can be formalised in mathematical terms through the concept of a giant component. A component of a network is a set of nodes that are all connected between them in the sense that it is possible to reach any node of the set starting from any other node in the set following a path of links. If we consider the largest component of a network, we can say that there is a giant component if the number of nodes $N_{LC}$ of the largest component scales with the size of the network N as $N_{LC} \sim N$.

Apart from the mathematical details, the existence of a giant component signals the fact that a sizable fraction of nodes belong to the same component, which we take as a proxy that the network can perform its function (for instance it means that information could travel among a relatively large set of nodes). In the absence of a giant component, the network is just a collection of components that are very small compared to the total number of nodes and are disconnected between them. So the network is not well-formed, and it does not display any large-scale coherence.

For network generated through the configuration model, it is possible to derive the following condition for the emergence of a giant component (Molloy and Reed, 1995):

$$\langle k(k-1)\rangle / \langle k\rangle > 1 \qquad (1)$$

where $\langle \cdots \rangle$ denotes an average over the degree distribution of the network. The equation above can be specialised to the case of Erdös-Rényi and scale-free networks. For Erdös-Rényi networks, the condition reduces to $\langle k\rangle > 1$, which means that if the average degree is larger than one the network displays a giant component. Notice that this implies that the giant component appears already for sparse networks (in a network of N nodes, there can be up to N (N − 1)/2. A network is said to be dense if the number of links scales with the number of nodes N as O(N2): If the number of nodes doubles, the number of links quadruples. A sparse network is instead one for which the number of links scales instead as O(N): If the number of nodes doubles, the number of links also doubles).

For an Erdös-Rényi network there are then two regimes: If $\langle k\rangle < 1$ there is no giant component, while if $\langle k\rangle > 1$ there is a giant component and the network and, in the abstraction, we are considering, can perform its function.

For a scale-free network with $2 < \gamma \leq 3$ the situation is quite different: The second moment of the degree distribution diverges, which implies that the condition for the existence of a giant component is always satisfied. The intuition behind this behaviour is that the presence of hubs facilitates the connectivity of the network, which is always able to perform its function.

Given that we are taking Erdös-Rényi and scale-free random networks as toy models of decentralised and centralised systems, the lesson we gain from this analysis is that, while it may be easier for centralised systems to function, decentralised systems can also operate well in the sparse regime, provided a sufficient number of links is present. Thus, IoV system designers would need to account for these network properties.

**Robustness of random networks**

We discussed so far what happens if we randomly connect pairs of nodes, and we were asking under what conditions a giant component emerges in the network. We now look at the opposite problem. We consider a network with a giant component, and we ask how many nodes we should remove for the giant component to disappear. This exercise is useful in order to understand how robust a network with respect to the failure of its nodes is.

The answer to this question is not clear. It depends on the protocol used to remove the network nodes. If nodes are removed randomly with uniform probability, scale-free networks are more robust than Erdös-Rényi networks. If nodes are removed, starting with the most connected ones, Erdös-Rényi networks are more robust than scale-free ones. The reason for this behaviour - often referred to as robust-yet-fragile behaviour - is simple: While in Erdös-Rényi networks nodes have similar degrees, scale-free networks are characterised by the presence of few hubs - which facilitate the connectivity between different parts of the network - and many "poorly" connected nodes. In that configuration, to break the network, hubs must be removed. However, if nodes are removed randomly with uniform probability, it is not likely for hubs to be removed, because they are few and with higher probability, a poorly connected node will be selected for removal. However, if the removal protocol favours the removal of highly connected nodes, then by removing a few selected nodes (the hubs) it is very easy to break scale-free networks (Cohen et al., 2001).

This intuition is extremely important for IoV systems. It confirms that a distributed network will perform worse than centralised ones in the case of random failures of nodes, while they will be better off in the case of targeted attacks that are aimed at breaking the system.

**Spreading processes of random networks**

We have so far considered the structural properties of networks. However, how does the structure of the network affect the outcome of dynamic processes that take place on the network? This question is useful to understand, for instance, how information spreads on networks.

Again, the degree of distribution of the network can strongly affect the outcome of dynamical processes taking place on networks. A typical example of this can be seen, for instance, in epidemic spreading models. Consider, for instance, the SIS model, where each node can be susceptible or infected. The dynamic is very simple: At rate $\alpha$, each infected node infects its susceptible neighbours, while at rate $\beta$ each infected node becomes susceptible (i.e. it recovers, but it does not become immune). In this spreading process, the question is raised, whether in the stationary regime, the fraction of infected nodes can be larger than zero. By solving the model, it is possible to find a condition for this to happen (Pastor-Satorras and Vespignani, 2001):

$$\alpha \langle k^2 \rangle / \beta \langle k \rangle > 1 \qquad (2)$$

This condition depends on the moments of the degree distribution, and it defines the so-called epidemic threshold, which discriminates between a regime where no infected nodes remain in the system and a regime where a finite fraction of nodes remain infected. The epidemic threshold is equal to $\langle k \rangle / \langle k^2 \rangle$ : if $\alpha / \beta < \langle k \rangle / \langle k^2 \rangle$ there is no epidemic, otherwise there is. The epidemic threshold crucially depends on the moments of the degree of distribution. In particular, we see that - at odds with the case of Erdös-Rényi networks where the two regimes exist - for a scale-free network it goes to zero, meaning that a finite fraction of the population will always be infected as long as the transmission rate $\alpha$ is larger than zero (Pastor-Satorras and Vespignani, 2001; Barrat et al., 2008). Again, this is due to the presence of hubs that facilitate the spreading of the infection.

Epidemic spreading models cannot be directly used to model the propagation of information in networked systems, as the propagation mechanism is context dependent. For instance, uninformed individuals may require multiple exposures to informed individuals to acquire the information, or informed individuals may decide to stop spreading the information if enough of their neighbours are already informed (Daley and Kendall, 1964; Daley and Gani, 2001; Barrat et al., 2008). Therefore, results concerning the efficiency of different networks may depend on the specific mechanism at hand. For instance, in the case when informed nodes stop propagating information if enough of their neighbours are informed, the presence of hubs may reduce the capability of the information to reach the entire network, should these stop propagating the information.

A real case application of epidemic spreading models to distributed systems is the study of forks in the blockchain, which may impact IoV systems. In this case, nodes represent miners who validate transactions and spend computational power to form new blocks to be added to the blockchain. The mining process can be modelled as a Poisson process on each node, where new blocks are discovered at a given rate. When a new block is found by a node, this is broadcasted at a given rate to its neighbours, who in turn broadcast the new block to their neighbours and start mining on the new block, and so on. This propagation process can be modelled as an SIS model with $\beta = 0$ (Decker and Wattenhofer, 2013), i.e. infected nodes (nodes that have been informed about the new block) never recover from the infection. A blockchain fork occurs whenever the new block does not reach the whole network before an alternative block is found by an uninformed node. The probability of a fork increases with the number of nodes in the network, which may lead to scalability problems.

In this context, the efficiency of the system can be, for instance, measured in terms of the probability of reaching the majority of the network before a fork occurs. A comparison between Erdös-Rényi and scale-free networks shows that the latter scale better (Caccioli et al., 2016).

**Conclusions**

The comparison between Erdös-Rényi and scale-free networks discussed above provides some intuition concerning the robustness and efficiency of IoV networked systems. The main points that emerge are the following:

- In Erdös-Rényi random networks, nodes are homogeneous in terms of their degree, while in scale-free networks, nodes are unequal because links concentrate on a few hubs. We can use these models as abstract examples of distributed systems and effectively-centralised systems.
- From a structural point of view, scale-free networks tend to be more efficient: They are more compact, and the presence of hubs make it easy to navigate through them.
- This increased efficiency comes at the expenses of a high fragility to targeted attacks: If a few hubs are shut down, the system breaks and will fail to perform its function.

More centralised systems, where special nodes serve as hubs, appear to be more efficient. This is perhaps the reason why many real networks that have no central planning (such as the Internet, cryptocurrency open networks or social networks) spontaneously evolved towards a structure that can be better approximated by scale-free networks than Erdös-Rényi networks. See Tasca P. 2015 for centralisation of the Bitcoin network (Tasca. P, 2015).

The reason for this tendency can intuitively be understood by the desire of nodes to establish connections with important nodes to facilitate their access to the system. This is at the basis of the celebrated Barabasi-Albert model of scale-free networks, which explains how a scale-free network may be the result of individual nodes' decisions. The decision-making process they use in their model is simple: As new nodes come to the network, they need to connect to already existing nodes. The choice of their neighbours is random, but with a bias such that the probability of connecting to a node increases with the degree of that node. This preferential attachment, rich-get-richer rule leads to a self-reinforcing mechanism by which the more connected a node is, the more new connections it tends to attract. This eventually leads to the emergence of hubs in the system and consequently power-law distributions of degree. This implies the existence of special nodes on which most of the activity in the network concentrates.

The same special nodes that improve efficiency make the system vulnerable to attacks however. Once the special nodes are identified, it is enough to focus on them to take the system down, so that the most efficient network structures are not necessarily the most robust to attacks. This represents a potential trade-off between efficiency and robustness to attacks which is of paramount importance for IoV systems: The network topology which is desirable for efficiency gains does not generally match the one that is preferable in terms of robustness against attacks.

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## Part B: Potential Sources of IoV Systemic Risk

*Josep Lluis de la Rosa Esteva*

With the continuous development of the IoV, the lack of interoperability between networks of trust can become an important source of systemic risk.

Indeed, the main problem blockchain technology faces at the moment for the sake of the IoV is the lack of interoperability and the obstacles faced in building a second and third layer network.

There are thousands of distributed ledgers out there today, and they perform or improve several functions. Each one of them is working separately like a local area network (LAN) of the 1970s that did not communicate with others around it; closed off because there is no adoption yet of industry-wide standardisation of protocols. If they could all interoperate, moving several digital assets and converting from one to another could be fast, cheap, and more secure, especially as there would no longer be a need to rely on risky centralised exchanges.

Even if the current financial system started adopting distributed ledgers on a large scale, with each institution using its own private or public ledger, not all of the challenges faced by today's siloed systems would be solvable. Paradoxically, in this scenario, the situation with cross-border and inter-bank transactions might remain the same as it would require time-consuming processes for value to move from one ledger to another.

Thus, interoperability is a must, and not having it is a potential source of systemic risk. This is of paramount importance especially in the current expansion phase where the IoV's new business models come up to erase long-standing barriers and enabling the democratisation of finance and property by empowering its users to transact instantly not only across borders but also across currencies while closing cultural and socioeconomic gaps.

The reasons for the lack of interoperability between ledgers are many, not only the lack of agreed standard protocols to make it possible, but the fact that every ledger has different goals when it comes to how data and the digital assets are handled. They are also built using different distributed ledger technologies, languages, protocols and consensus mechanisms. For more insights about the blockchain interoperability issue, we refer the readers to Tasca and Piselli (2019).

The lack of interoperability – driven by the diversity of missions and technological proposals for ledgers – is not the only source of systemic risk that we envisage. Also, the lack of scalability of these new network technologies could worsen the risks of assets and value, in general, being lost in endless sidechains.

Sidechains, state channels, payment channels are off-chain solutions to specialise the validation of transactions in subsets of nodes. An off-chain transaction is the movement of value outside of the *main* ledger, despite being very likely registered in a local or minor ledger validated by subsets of nodes from the main net, which in their turn tend to be trusted parties among each other and work out in a permissioned minor ledger (Back et al., 2014).

Then only a "summary" of this minor ledger is uploaded on the main ledger in any form that is eventually validated by the main net. Risk is again at the core of this specialisation. If this is the technology which will be used for a hyperconnected IoV, we may expect that from time to time tokens might get trapped in these new siloes or might take the wrong direction in the network, and therefore their value might fade according to their distance to the main net and the number of summary hops that are required to get the greatest level of confirmation.

To summarise, considering the current growing trend of open communities along with all types of permissioned ledgers, and the developments of side-channels for speeding up consensus for those who transact at high volume or demand higher privacy or speed, the lack of scalability and interoperability are major risks.

Of course, also the network structure – as discussed in the previous Part – plays an important role. Especially if we think of networks of networks, see, for example, coloured coin applications (Bitcoin Wiki, n.d.). This source of systemic risk is of paramount importance as numerous new initiatives are proposing services backed by collaterals in whatever asset that is tokenised (i.e. lending, factoring, insurance, guarantees of service, creative industries, and more). The trend of collateralising the risk of digital currencies or any of the new digital assets may lead to systemic risk.

In the case of crypto-collateralised stablecoins, conceived as a workable truly decentralised approach to stabilise prices in the distributed ledgers world, are unstable. The same might happen with crypto-collateralised loans, that are paid by smart contracts collateralised by cryptocurrencies. For example, "*when you want to take a Dai loan from MakerDAO, you freeze some Ether in MakerDAO as a guarantee that you will repay your loan. As the US mortgage market collapse of the 2000s has shown, Collateral is an unstable asset whose price may decrease significantly*" (Heydari, 2018). Under these assumptions, the stablecoins' smart contracts might demand several times more collateral than the original value of the loan.

The phenomena of the IOV presents an interesting avenue to the application of tokenisation to new business models that may lead to systemic risk. The IoV facilitates value moving as quickly and as easily as information does. Since value is something that is up to a society to determine, there is practically no limit to what can be exchanged over the Internet with value for individuals or institutions. According to Heydari (2018), today, cryptocurrencies have attracted 5% of gold market customers to reach a $400 billion market size. If stablecoins happen to reach 1% of today's money market size someday, they would have an $800 billion market.

Therefore, another source of systemic risk may come precisely from the nature of digital assets used as collateral. Tokenisation and collateralisation might create new types of much more complex asset interdependencies, and the collapse of even a small asset used as collateral could trigger a domino effect of a failure cascade.

Some collaterals value might fade by their lack of usage, trust, lost in a minor ledger, and indeed because they are poorly preserved. Finally, we will focus precisely on the preservation of collateral value over time. The preservation of value is tackling the problem of value loss through time and exchanges (Rosa, 2019). Through time, the accumulation of errors that occur when updates and migration into new technologies take place, tend to erode the usability and integrity of digital assets. Thus, their value may reflect this situation and suffer a devaluation as they would not be ready for any value transaction as the receiver will not receive the assets at their full integrity in the form and time that is required. Similarly, the accumulation of errors in the transmission of value to inappropriate receivers impacts the value that goes on erosion. The two factors, obsolescence and bad exchanges multiply, accelerating the decrease in the value of digital assets.

Thus the development of techniques that look after the curation and integrity of digital assets along with their proper ownership management across all exchanges is all about the preservation of value, as an ultimate safeguard to avoid systemic risks triggered by a failure to preserve the value of digital assets.

To conclude, there has been a discussion of some potential sources of systemic risk to the emergence of the IoV. However, it is difficult if not impossible to be exhaustive on all possible sources. Indeed, the recent 2007-2008 financial crisis showed that with increasing connectedness comes increasing complexity, which is understood as greater interdependence. Any increasingly complex system is also characterised by higher unpredictability, speed, and presents emergent properties that are not observable at the micro level, leading to higher fragility. For further discussion on economic complexity please see Sahdev (2016).

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# Chapter 8: Governance and Privacy Issues from the IoV

*Mike Brookbanks*

The IoV is a functional layer on top of the Internet that enables decentralised digital economies and value transfer. The vision for the IoV is for any quantum of value to be exchanged as quickly and fluidly as information is today.

Providing a distributed network with the so-called trustless trust, where users trust the outputs of a system without trusting any actor within it, blockchain serves as an ideal architecture for the realization of the IoV. The promise, or threat, of blockchain, is to challenge centralized, top-down decision-making through radical transparency and smart contracts composed of auto-enforceable code. Deemed as home to "money without banks, companies without managers, countries without politicians", blockchain faces the issue that the on-chain governance is often misaligned with privacy rules and regulations.

This chapter is written by Mike Brookbanks, who considers the challenges and risks arising from the IoV on governance and privacy that are apparent with the transfer of trust and risk. It considers the current governance and privacy issues with the development of new digital services such as blockchain, that underpin the IoV, and how these issues need to be addressed.

This Chapter was created with the support of Danielle Mendes Thame Denny and reviewed by Alexandra Sims.

## Introduction

Within the current supply chain, the trust between producer to consumer associated with the transfer of value is established through the development of legal contract and established relationships – through and with central counterparties (Banks, Agents Regulators, Government Departments etc.). The blockchain creates a Value Web of relationships (Cartwright, 2000; Block et al., 2008) between all participants/entities (including the producer and consumer). New collaborations between entities are becoming established, which shift and threaten the 'established' governance frameworks. Aligned with this, there is a level of 'governance' and 'privacy' that is developing 'bottom-up' within blockchain technology as auto-enforceable code and smart contracts. It is being built with new organisational entities such as the DAO[45]. New enterprise-level governance and privacy frameworks/models and standards need to be developed to address the changing trust/risk models between consumers and suppliers.

There is a large gap between on-chain developments and the enterprise level of governance and privacy required by governments and regulators, for example how are the data privacy requirements set out in GDPR[46] to be addressed 'on chain'?

While existing literature provides several models on technology governance, its role, and how it interrelates with corporate/business strategy and delivery of technology to the business (Wu et al., 2015), the current view of technology governance still does not address the particular requirements of changing business models within the IoV. It is still disconnected from corporate/business strategy (Valentine, 2016).

There is also a developing body of work to creating the underlying standards for blockchain. ISO/TC 307 with working groups focusing on both privacy and governance within the Blockchain. These new standards do not address the broader socio-economic issues of the IoV, and new frameworks are required to address both the distributed/collaborative governance and privacy of the IoV. With the implementation of digital services, there will need to be a degree of flexible adaptation of the business models and governance within the IoV to address the disruption driven by technology change.

## Governmental/regulatory governance

To date, many of the digital services within the IoV have been developed based on financial services and technology companies such as Hyperledger, Ethereum, R3 (Corda) and Facebook (Libra). The development of these services is now being established across industry, in government, manufacturing and retail; where supply chains are being both enabled and disrupted by blockchain-based digital services.

It is clear that technology companies continue to promote the development of these innovative digital services between consumers and suppliers with scant regard for the way that the trust/risk dynamic will shift as the value chain changes and new intermediaries are introduced. This presents governments and country regulators with a problem of governance and privacy. They want to promote the introduction of innovative digital services (Holmes, 2017):

- to improve trust (Berry et al., 2015; Hurley et al., 2014) and inclusion (CPTM, 2016),

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[45] The DAO (stylized Đ) was a digital decentralized autonomous organization, and a form of investor-directed venture capital fund. The DAO had an objective to provide a new decentralized business model for organizing both commercial and non-profit enterprises.

[46] The General Data Protection Regulation 2016/679 is a regulation in EU law on data protection and privacy for all individual citizens of the European Union and the European Economic Area. It also addresses the transfer of personal data outside the EU and EEA areas

- as a way of resolving longstanding economic problems, improving financial inclusion (Krause and Pearce, 2016; CSJ, 2016)
- to address change in the political economy (Cohn, 2016) to create new markets.

While they have to ensure the problems of the past are not repeated, they also have to make sure that risk within the market/value chain between consumers and suppliers is not increased, and that trust and privacy between participants are maintained. The challenge is that social, economic, cultural, ethical, legal, governance and risk models that govern the introduction of innovative digital services are nascent (Walport, 2016; CPTM, 2016; Adams, 2017). None of the prime movers within the technology companies and financial services companies have a history of responsible innovation. Governments and regulators need to promote the development of innovative digital services and markets as part of the IoV while ensuring that the innovation is responsible, governed (Stirling, 2016; Valentine, 2013), and that privacy and risk are managed (Chiu, 2016; Walch, 2015). The Bank of England recently announced policy and rules of engagement for Facebook's Libra (Bank of England, 2019) which demonstrate how the creation of this blockchain-based payment system should be regulated by the standard banking rules.

Unfortunately, the standard banking rules are not aligned with the changing digital economy. Therefore, country policymakers, governments and regulators also need to consider how blockchain would change the existing frameworks and regulations. These governance and regulatory frameworks need to cover all aspects of the IoV - to cover legal, process and technical standards. It should be noted that supervising a blockchain and DLT 'network' is more complex than supervising current central market infrastructures, in particular considering that different nodes might be established in different geographies/jurisdictions and subject to different privacy, insolvency and other requirements. The IoV will operate across the globe, so governance and privacy need to consider these challenges in the development of their regulations and standards.

The IoV will reduce barriers to entry, introducing a borderless economy which will impact commercial and individual privacy[47] where it is typically focused on the ability of any one legal entity to protect the privacy of its citizens through public policy. The actions of public and private organizations that operate outside its borders within the IoV will need to consider privacy and its legislation as a key requirement (Catalini, 2016). In a commercial context, privacy entails the protection and appropriate use of the personal information of customers, and the meeting of expectations of customers about its use (Pearson, 2012). What is appropriate will depend on the applicable laws, individuals' expectations about the collection, use and disclosure of their personal information and other contextual information, hence one way of thinking about privacy is just as 'the appropriate use of personal information under the circumstances' (Swire, 2007). Today, big technology companies and financial institutions have almost the monopolistic power on data about personal identities and transactions. Private data has become, by far the most valuable asset when data analytics and artificial intelligence are used to develop new commercial models leveraged by private data (Akgiray, 2019). These new technologies are straining the traditional legal frameworks for privacy. Today people willingly and freely supply their private information and then lose control of their privacy[48]. As more information

[47] There are various forms of privacy, ranging from 'the right to be left alone' (Warren, S.1890), 'control of information about ourselves' [Westin, A.1967 , 'the rights and obligations of individuals and organisations with respect to the collection, use, disclosure, and retention of personally identifiable information.' [AICPA,2009], focus on the harms that arise from privacy violations [Solove, D.J, 2006] and contextual integrity [Nissenbaum, H,2004]

[48] Privacy differs from security, in that it relates to handling mechanisms for personal information, although security is one element of that. Security mechanisms, on the other hand, focus on provision of protection mechanisms that include authentication, access controls, availability, confidentiality, integrity, retention, storage, backup, incident response and recovery. Privacy relates to personal information only, whereas security and confidentiality can relate to all information.

is known, recorded and accessible, it makes it difficult for people not to be judged on the basis of past actions. Traditional assumptions about responsibility, legal liability and the possibilities of control, the privacy problem has recently assumed a far more complicated and global profile. Thus, the enforceability of information privacy laws is obviously undermined if organizations can escape strict regulatory responsibilities by instantaneously transmitting those data to other jurisdictions for processing (Pearson, 2012).

While privacy is regarded as a human right in Europe, in America, it has been traditionally viewed more in terms of avoiding harm to people in specific contexts. It is a complex but important notion, and correspondingly the collection and processing of personal information are subject to different regulations in many countries across the world.

Most privacy laws across the world were created before the Internet, resulting in gaps between the guidance that laws and regulations can provide and decisions that organisations need to make about the collection and use of information. Organisations processing personal data need to ensure that their operations comply with applicable privacy regulations as well as with consumer expectations, but this can be very challenging. In a 'borderless world', created through the IoV, public policies to protect personal privacy are inextricably interdependent (Bennett and Raab, 2006).

New privacy risks are emerging, and the capacity to cause consumer harm has increased dramatically (Pearson, 2012). Therefore, companies must find ways to integrate ethics, values and new forms of risk assessment within their organisation, as well as demonstrating responsible practices. Conforming to legal privacy requirements and meeting client privacy and security expectations with regard to personal information require organisations to demonstrate a context-appropriate level of control over such data at all stages of its processing, from collection to destruction. Privacy protection builds trust between service providers and users, and accountability and privacy by design provide mechanisms to achieve the desired end effects and create this trust. This management can span a number of layers: policy, process, legal and technological. It is universally accepted as a best practice that such mechanisms should be built in as early as possible into a system's lifecycle.

Legal issues, such as the legality and enforceability of the records kept on the blockchain, also need to be carefully considered. Differences in laws across countries may interfere with a wide deployment of the IoV across complex multi-country supply chains.

Therefore, governments and regulators need to collaborate and consider how the legal, process and technical standards will need to change and adapt concerning associated standards and governance.

Common standards (legal and technical) are required to ensure that the IoV does not add another layer of complexity on markets between suppliers and consumers. Indeed, while blockchain should in principle enhance the traceability of transactions and hence transparency, the encryption of the information could make it harder to disentangle it and to process it, at least in the short term. This would effectively render supervisory work more challenging. Blockchain and DLT standards and governance need to be introduced in each country to control/manage the adoption within the country and between countries. From a common standard view, ISO 307 is developing a governance/regulatory technology standard. Within countries, regulators need to consider the developing standard-based frameworks to govern the interactions between participants, both 'permissioned' and 'non-permissioned'. These rules would need to address many potentially complex issues. Examples include the liabilities of the respective participants in case of, e.g. fraud and error, correction mechanisms and penalties in case of infringement to the rules, the intellectual property attached to the technology or the territoriality of the law likely to apply to the network.

**Corporate/technology governance**

Standard approaches of corporate social responsibility nor responsible innovation (Blok & Lemmens 2015; Stilgoe et al., 2013) cover the momentum building behind the development of innovative digital services within the IoV. Operational/Technology governance and the responsible management of innovation, within corporates and industry, is also at the early stage of development (Blok & Lemmens, 2015) in light of the disruptive nature of digital channels and technologies. Valentine (2016) states that boards of directors, who have the ultimate legal responsibility for the strategic future, performance, and conformance of their organisation, have both ethical and fiduciary care responsibilities to be competent to govern technology. While Industry and government have developed the precautionary principle especially in their drive to manage the governance of technology (Stirling, 2016), this also does not address the specific nature of disruptive digital technologies (Blockchain, AI, Big Data) on business. There is clearly the need to control the development of online digital-based services and markets by ensuring responsible innovation (Stilgoe et al 2013) and technology governance (Stirling, 2016) and how risk is managed (Chiu, 2016; Walsh, 2015).

The research into technology governance needs to be focused on using digital technologies and innovation responsibly so that it is developed to promote creativity and opportunities that are socially desirable and undertaken in the public interest (EPSRC 2017). Gordon (2013) highlights the missing link between Information Technology (IT) governance and strategic alignment of boards, within different industries. As Gordon (2013) concludes, there is not a significant relationship between IT strategic alignment and levels of IT governance structure and federal IT governance structure. To be effective technology governance should support three main objectives: "(a) regulatory and legal compliance, (b) operational excellence, and (c) optimal risk management" Robinson (2005). What has changed since this study is the adoption by business and industry of new disruptive digital technologies. That development of these will have a significant impact on the overall corporate governance for boards of directors. Since blockchain's biggest promise is the elimination of some or all intermediaries, it offers a great opportunity for better corporate governance. There is not much discussion of this view of corporate governance on the blockchain, and it is, therefore, worth exploring. It is interesting to map the basic purposes of corporate governance against the basic properties of blockchain technology against the key areas of corporate governance, as seen in table 10.

| Areas of Corporate Governance | Properties of Blockchain |
|---|---|
| Transparency | Shared distributed ledgers |
| Accountability | Irreversibility of records |
| Responsibility | Peer-to-Peer communication |
| Fairness | Smart contracts (?) |

*Table 10: Properties of corporate governance against properties of blockchain*

Also, Valentine (2016) calls for boards to step up to their technology governance responsibilities, and the link to their key measures of share price, revenue, and profit, through reputational risk. As stated by Aula (2010), reputational risk is a top concern for many boards as the current impacts of product failure are immediately reported in social media, which while affecting the share price also has an impact on the consumer/supplier trust relationship. "*The loss of reputation affects competitiveness, local positioning, the trust and loyalty of stakeholders, media relations, and the legitimacy of* *operations, even the licence to exist... leading European managers to consider reputation risk to be the primary threat to business operations and the market value of their organisations*" (Aula, 2010, p. 44). The conduct of the company, the associated operational risk, and trust in the company all reside as the responsibility of the board in the drive to strengthen corporate governance (Child and Rodrigues, 2004). From the literature review, it is clear that technology governance and the link between risk and trust is a developing and a required area of research, especially in financial services, where there is the unstoppable drive to adopt new technology to try to gain market advantage.

Technology governance detailed within literature can be viewed from diverse perspectives, but again the focus is on supporting standard delivery models and supply chains. It does not address the emergent IoV and the disruption this will have on trust, risk and established supply chain relationships. Technology governance should be considered as part of the overall governance within a business - linked to the Corporate/business strategy and the actual delivery of technology (IT) that supports the business as shown in figure 9.

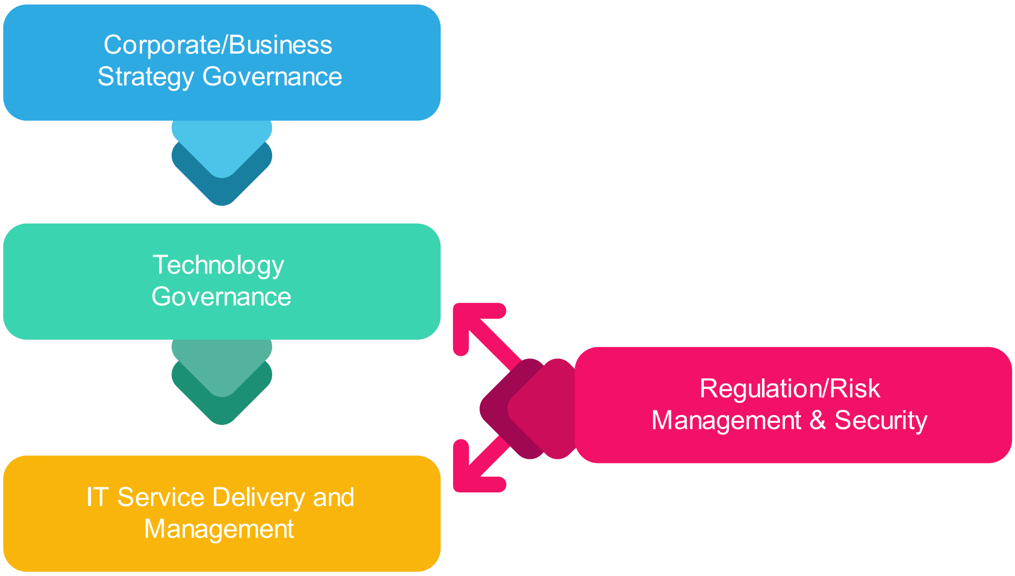


*Figure 9: How various strategy, governance and risk management areas relate to IT*

There are several views of Technology governance from the literature; Peterson (2004a) examined technology governance as organisational capacity exercised by the board, executive management and IT management. Weill and Ross (2004a) go as far as requiring senior levels to specify decision rights and an accountability framework to encourage desirable behaviour in the use of technology. This view of technology governance in this context is primarily concerned with IT project selection and prioritization issues and how the authority for resources and the responsibility for IT are shared between business partners, IT management, and service providers (Weill, 2004; Weill and Ross, 2004, 2005). That "effective IT governance deploys three different types of mechanisms: decision-making structures, alignment processes, and communication approaches." In their scheme:

- Decision-making structures are organizational units such as committees, executive teams, and business/IT managers responsible for making IT decisions.

- Alignment processes are formal processes such as IT investment proposals and evaluations that ensure IT alignment with organizational policies.
- Communication approaches are announcements and channels that spread principles and policies of IT governance and decision-making outcomes. Weill and Ross argue that effective governance deploys these three mechanisms, which in turn promote desirable IT behaviours and lead to desired performance goals.

Weill and Ross (2004) state that technology governance consists of the decision rights, incentives and the accountability framework to encourage desirable behaviour. This includes the foundational mechanisms in the form of the leadership and organizational structures and processes that ensure that the organization's technology sustains and extends the organization's strategies and objectives". What is missing in this definition is the context, in that the technology governance needs to integrate with the business strategy and delivery requirements. van Grembergen (2004) believes that technology governance includes 'the combination of leadership, structures and processes' and it will achieve the fusion of business and IT '.

All these views are required to ensure that IT sustain and extend the organisation's strategies and objectives (IT Governance Institute, 2003). In this way, technology governance has become an important integral part of corporate governance (Koo et al., 2010). That technology governance within a business should focus on the organisational alignment, integration and relationships. It is apparent that benefits arise when technology and business activities are aligned so that they both have the objective of achieving organisational goals (Gordon, 2013). In terms of business, technology provides the means to integrate organisational activities by eliminating duplication and bottlenecks. The activity of governance itself improves the understanding, and hence the working relationship, between technology and the rest of the business. As a result, benefits can be readily identified, such as returns in the form of increased revenue/ profits, and the balance struck between value creation (risk-taking) and security (risk managing). What though is apparent is that the various detailed concepts of technology governance are still evolving, mainly because of ''the specialisation and disconnectedness between globally-dispersed IT governance interested communities'' (Peterson 2004b, p. 41), that are appearing with the IoV.

There are several bodies that have developed IT technology governance best practice frameworks, including:

- the IT Service Management Forum (n.d.),
- the Information Systems Audit and Control Association (ISACA) and Information Technology Governance Institute (ITGI).

The most widely adopted frameworks according to Stafford (2003) are COBIT (Control Objectives for Information and Related Technology), ITILw (Information Technology Infrastructure Library), and ISO17799: 2000 (International Standards Organisation). COBIT was originally developed by ISACA in 1996. It is a high-level governance and control framework and views IT from a control and process perspective. In doing so, COBIT aims to ensure that IT is aligned with the business, to maximise benefits from the use of IT, to use IT resources responsibly and to ensure IT risks are managed and mitigated. ITILw is a service management framework developed by the UK's Office of Government Commerce in the 1980s to use IT resources and services better (ITIL, n.d.). It was originally very much a process-oriented framework but has evolved into a more lifecycle-centric approach in its recent release (Version 3). While COBIT articulates ''what'' needs to be done, ITILw focuses on ''how'' to do it and ''who'' should perform each task.

To implement technology governance effectively, mechanisms are required to ensure there is integration with mission, strategy, values, norms, and culture and to promote desirable IT behaviours and governance outcomes (Weill and Ross 2004). The technology governance mechanisms are often indicative of an organisation's (both IT and business) capability (Bradley et al., 2012; Karimi et al., 2000) and performance. Technology governance is critically important as it is seen to have a substantial impact on the value generated by the investment in IT. In fact, Weill and Ross (2004, pp. 3-4) argue that "effective IT governance is the single most important predictor of the value an organization generates from IT." It is seen that strategic alignment can be achieved by implementing well-designed technology governance mechanisms. As noted by Huang et al. (2010, p. 288), "well-designed and orchestrated IT governance mechanisms are expected to produce technology-related decisions, actions and assets that are more tightly aligned with an organization's strategic and tactical intentions."

In summary, the governance of technology - including IT is still developing; there are a number of differing approaches/frameworks that are interpreted by enterprises to meet their organisational goals. That the new business models within the IoV need to be considered with developing new governance frameworks that at least link governance mechanism, strategic alignment and organisational performance (Wu, 2015). The collaborations between entities within the development of the IoV challenge the normal models.

In summary, while there is a body of work detailing governance and privacy with established frameworks for the delivery of technology, these are outdated and do not address the changing trust and risk challenges of the IoV (nor the underlying digital technologies). This governance and privacy gap have been recognised within the new digital technologies and developments, and collaborations between parties are trying to address the gap.

More formal research is required 'top-down' to ensure that the current 'bottom-up' approach does not address the regulatory and control requirements from the business. New businesses and business models developing within the IoV and the blockchain economy will be constrained when outmoded governance is introduced (Bank of England, 2019) that stifles innovation.

**Practical development of governance and privacy with the IoV**

Blockchain, the innovation that underpins the IoV, determines that the network of participants is open, and participants do not need to know or trust each other to interact. On a blockchain, electronic transactions can be automatically verified and recorded by the nodes of the network through cryptographic algorithms, without human intervention, central authority, point of control or a third party (e.g. governments, banks, financial institutions or other organizations). Even if some nodes are unreliable, dishonest or malicious, the network is able to correctly verify the transactions and protect the ledger from tampering through a consensus mechanisms *proof-of-work and the developing proof of stake* which makes human intervention or controlling authority theoretically unnecessary (van Rijmenam et al., 2017). The decentralized trust or trust-by-computation and its importance can hardly be overstated: indeed, it represents "a shift from trusting people to trusting math" (Antonopoulos, 2014), with applicability that goes far beyond the creation of decentralized digital currencies (Atzori, 2015). With the recent development of new digital platforms, products and services have become more and more unbundled, bringing producers and consumers closer to each other. Historically the terms of service have always dictated that one or more trusted third party/organisations are present within the supply chain. The IoV, blockchain and smart contracts can disintermediate these third parties, introducing new ways of coordinating activities such as task allocation, coordination, and supervision of a group of people who share common economic interests but are geographically distributed, without the necessity of a centrally managed organization.

The blockchain, underpinning the IoV, with a distributed configuration, can produce an acceptable solution for privacy. However, full “privacy control” is yet far from being realized. On a blockchain, users have “pseudonymous” identities, and hence their real-world identities are largely protected via private key cryptography. However, details of transactions are still fully transparent because the distributed ledgers are shared by all. To protect their privacy, users can adopt privacy-enhancing techniques (e.g. use a new address for each transaction, obfuscate their transactions by mixing them with others), rely on an intermediary (e.g. a digital wallet provider), or use a system that separates basic information about a transaction (e.g. its existence and timestamp) from more sensitive attributes.

Additionally, sensitive information could be stored on a private blockchain (or database) and immutably linked to the public blockchain entry using a digital fingerprint (Athey, 2016, 2017). While this is still an active area of research, new protocols are being developed to obfuscate transaction data, these offer full anonymity to users through zero-knowledge cryptography and implement different degrees of access to transaction information. Although perfect obfuscation might not always be possible to achieve,[49] it is clear that different blockchain implementation will be able to compete also in terms of the privacy level they provide to their users (either at the protocol level or through a trusted intermediary). When combined with privacy-enhancing measures, this can solve the trade-off between users’ desire for customized product experiences and the need to protect their private information. If the sensitive data is stored on a blockchain, users can retain control of their data and license it out as needed over time.

What is apparent is that governance and privacy do need to be established in a ‘management blockchain’ where smart contracts are formed from the governance and privacy rules. The ‘management blockchain’ is then linked to participant technologies and provides the ‘control function’ required.

**Collaborative governance of the IoV**

Many of the practical developments to date for the IoV and blockchain have been collaborative, requiring cooperation among multiple participants. Governance of these collaborative organizations is critical to the success of these projects. Many enterprise blockchain solutions will be implemented by a "consortium" of enterprises, building one or more applications on top of a "blockchain platform." for example we.trade and Voltron in trade finance (Rutter, 2017)

Established organisations, corporates and central governments have also been using the concept of Fintech (Chiu, 2016; Puschmann, 2017) as incubator technology functions within their organisation to lever new technology, innovation and deliver new solutions that will affect a change in the culture, internal trust, business model, the market and supply chain. While this is an attempt to change the way, they manage and govern the development of technology; some innovators are embarking on deploying new technologies without a clear vision nor a link through strategic alignment to the business model, technology governance or risk.

Blockchain and DLT are a relatively base technology which when developed with toolboxes (e.g. Hyperledger Fabric) can have their functionality easily extended. Research shows (Rutter, 2017) that the current approaches to the development of blockchain technologies typically consider a relatively small business problem, e.g. the provenance of a single good - wine, diamonds, spinach, or a micropayment between counterparties. The developed solution is then progressed through the iterative development of the business problem. The business problem is then extended to new areas,

[49] See https://www.iacr.org/archive/crypto2001/21390001.pdf (accessed 08-01-2016).

adding in complexities of the supply chain, and then developing the technology. Therefore, the governance of the technology should follow this iterative cycle, developing as complexity is added.

Consortium technology governance will be as important to enterprises as "blockchain platform" governance because the enterprises will work with this level of governance daily. Consortium Governance “permeates” through all aspects of the blockchain, governance is an integral component of a sustainable network." (Cuomo, 2019).

There is a thought that the challenges of governance in blockchain project consortia are very similar to those solved (and continuing to be solved) by open-source software. When the requirements for governance within the enterprise are considered as detailed earlier, combined with the position of the IoV to change the trust/risk and value models. The IoV does require a more sophisticated governance and privacy model – than developed for open-source software.

The contributors within the collaboration for the IoV are a mix of industry practitioners, government/regulators, and academic scholars. As an example, Linux was created through a collaboration of developers to form an open Unix based operating system; this has now been extended to other areas of application development.

Technology governance and privacy of the IoV could be based on the principles to ensure that all stakeholder groups in the ecosystem are represented, focus on and address the following issues: implementation of the business model for the consortium (business to business, business to consumer), determine intellectual property ownership and licensing, and determine how to raise and spend funds to support the blockchain project. These principles will need to be expanded to address the vertical and horizontal gaps in governance that are seen within the developing IoV.

While most blockchain consortia will be governed through traditional entities, an alternative is a "contractual joint venture" in which all the rights and obligations are managed by a single contract. However, in this model, the participants are likely to have "joint liability" for funding shortfalls and disputes with third parties. Decision-making can also be difficult since the approval of all members may be required to act. The choice of geographic entity is key as seen within the Reducing Friction in Trade – Wine project; complications occur with multiple geographies are involved.

The stakeholders in the blockchain project consortium also need to be identified in order to determine how such stakeholder classes will be represented and how the authority to make decisions will be allocated.

The Reducing Friction in Trade – Wine programme includes companies in the industry, service providers to these companies (for example, freight forwarders in logistics blockchain project consortia), academic institutions, nonprofit institutions, software developers and users of the blockchain project. The consortium will also need to determine if the rights of the initial members will be different from later members. Once the various stakeholder classes have been identified, the programme board decide how they will be represented and structured. The current programme board represents the major stakeholders in the Reducing Friction in Trade – Wine programme. Collaborative governance is still evolving.

**A way forward**

Today, standard governance and privacy frameworks are mostly organisationally bound, and they are not orientated to support developing digital technologies and the distributed nature of the IoV. It is also established (Valentine, 2016) there is a disconnect between technology and corporate governance and the risk/regulatory standards and the technology delivery processes (Wu, 2015).

There are gaps between a business's strategy, corporate governance operations, risk management, technology governance and delivery within an organisation - vertical integration is missing for digital technologies. Most developments were made in the 1990s, and 2000s and they are not aligned to the drivers of this decade.

With the introduction of IoV, more horizontal integration gaps appear, as each stakeholder has a different set of strategies, processes, organisations and drivers. The IoV is developing new trust, value and risk business models across stakeholders from different organisations. Therefore there needs to be the development of new frameworks – that address the changing decision rights, accountabilities and incentives, communication, organisational constructs. These need to meet the multi-stakeholder, distributed nature of this new world.

There is no single framework that addresses the vertical gaps within an organisation and the horizontal nature of the distributed business models established through the IoV.

Clearly, there are new building blocks being created that could support the framework

- Organisational - with collaborative governance developing cross organisation,
- Technology standards for technology governance and privacy – as standards ISO 307
- Current business governance mechanism that have been established within an organisation (which is often disconnected today)

What is missing is the process to develop the new governance, and privacy frameworks – that considers the new business models within the IoV and iteratively uses components from the building block to continually develop the governance mechanism. The implementation of governance is not a one-off task; technology governance and privacy need to adapt as the business models within the IoV develop continually. Leaving governance to the technical developments and embedding it 'on-chain' risks the stakeholders, the consumers and suppliers within the IoV.

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