DIGITAL ISSUANCE

Digital Issuance – An Optimal Model for Digital Assets and Transactions

Full Report

Digest

This paper describes an opportunity for radical change: this change can drive extensive improvements in the experience of investors and borrowers, and in the economics of investment. The opportunity is open to all participants in the financial markets, including their regulators; it is not targeted specifically at the buy-side or the sell-side, and it doesn't favour service providers, platform vendors or direct market participants.

The opportunity is presented by digitisation. We look at transactions and assets and ask how they may be best represented in a digital form. We define a model which is optimised for digital issuance, rather than replicating the attributes and behaviours of conventional assets and transactions into a digital world.

The paper seeks to show how rethinking our view of assets and transactions can lead to remarkable benefits: a common form of representation for digital assets is possible across asset classes, and a single digital operating model is practical and achievable as a result. This will deliver transformative improvements in financial products both for investors and for the issuers of capital.

The Author

Dr Ian Hunt is a recognised authority on buy-side operations, investment processes and technology. He is an independent advisor to Moody's Analytics on buy-side innovation and design lead for FundAdminChain, a digital fund trading platform, as well as an advisor to a number of innovative fintechs. Dr Hunt has consulted for many leading investment managers and asset owners in the UK, Europe and the USA, and is particularly known for his work in Distributed Ledger Technology (DLT) and the Investment Book of Record (IBOR). He has acted as the Investment Expert on a series of Madoff trials and other investment fraud cases. Dr Hunt is a Freeman of the City of London, and has a BA in Philosophy, an MSc in Computer Science and a PhD in Mathematical Logic from University College London.

Digital Issuance Papers

This white paper is an abbreviated version of a full report, covering the same ground in more depth, and published simultaneously. Both papers aim to show why we need a coherent approach to digital assets, to define an optimal model for digital issuance, and to demonstrate that this model is sound and can deliver substantial benefits. The point is to define a target, and to show that it is a good target; how we get there comes later. The author expects to produce follow up papers, focused on implementation, and addressing different asset classes and product types in more detail.

Sponsors / Supporters

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Caveat

The opinions expressed in this paper are those of the author, and there is no implication that they are approved or supported by any other individual or organisation, including those identified as sponsors, as supporters, as editors / reviewers, or as clients of the author. The parties who have contributed to the paper share one view, which is that the subject of digital issuance is important and needs widespread and intelligent debate.

Structure

Foreword

At the Investment Association (IA), we are committed to supporting the industry in exploring the opportunities that new technology and innovation offer; digitisation represents a key part of this. It is an area that is gathering momentum and represents a major opportunity for the investment industry. The UK Government has announced that it intends to make Britain a global hub for cryptoasset technology and to explore the potentially transformative benefits of Distributed Ledger Technology (DLT). To make constructive progress towards this, we need a collective focus, regulatory buy-in and cross-industry engagement: the IA will work hard to facilitate that.

This paper articulates the need for an optimal and secure approach to digital asset issuance, and an efficient and secure approach to digital transactions. It paints a picture where digital issuance can be consistent across asset classes, and a single operating model can support the management of both assets and transactions.

Whilst the IA may not necessarily agree with every position taken or model proposed in this paper, we do see it as an important contribution to a vital industry topic.The author, Dr Ian Hunt, is a prominent innovator in investment process and technology. The IA has worked with Dr Hunt on previous initiatives in Distributed Ledger Technology and fund tokenisation and this current paper builds on these foundations to lay out and theorise how digitisation could present a new market infrastructure model.

Digitisation and the use of distributed ledger technology in the sector is at an early work-in-progress stage and this presents the industry with a chance to create thoughtful dialogue and effect positive change. We can look at the application of this technology as it applies to the pre-existing market structure, but we can also consider how it might work outside these constraints, as this paper lays out. We know that the pathway towards a more digital world will not be quick or straightforward, and that there will be many solutions and paths to reflect on, but we also know that it is a journey with many potential benefits to realise. As an industry, it is up to us proactively to pursue conversations on what these transformative benefits may be, and how they will work for the good of all market participants, most notably for the end investor.

We intend to run member forums on the subject of digital issuance, following the publication and launch of this paper, and look forward to wide industry participation in these events.

Chris Cummings - Chief Executive, The Investment Association, May 2022

Glossary

The Global Blockchain Business Council (GBBC) has developed a taxonomy for terms relevant to tokenisation, blockchain and distributed ledger technology. This is known as the Global Standards Mapping Initiative (GSMI), and in November 2021, version 2 was launched, logically making it the GBBC-GSMI 2.0[1]. Where relevant, the glossary below follows, or is consistent with, that standard. However, as the smart token model proposed in this paper goes well beyond the current capabilities of decentralised platforms, the glossary offers definitions for many other model-specific terms.

Advertisement	A Smart Token, or a cluster of Smart Tokens, held and visible on the Issuer's Node, indicating that the Issuer is willing to trade on the Terms of the Pledge or Pledges coded on the Smart Tokens. Similar to an IoI
Beneficiary	The receiver and holder of a Pledge from an Issuer, coded onto a Smart Token. The same as Recipient
Bi-Directional Flow	An exchange of Tokens, where both parties are Issuers and Recipients, and Tokens Flow both ways when Triggered
Blockchain	A database that places records of transactions in blocks on a Distributed Ledger network. Each block is linked (or "chained") to the previous block, using cryptographic Signatures, that together make the transactions they contain immutable
Central Bank Digital Currency (CBDC)	Digital cash Tokens issued by (and as a liability of) a jurisdiction's central bank or other monetary authority, and denominated in that jurisdiction's national currency
Cluster	A set of Tokens, with or without an attached Label, used for trading purposes, or as an aggregation key for valuation or risk
Circle of Interest	In the context of this paper, a permissioning definition whereby a Node specifies which other Nodes, and which Smart Tokens, can have visibility of Smart Tokens, and therefore of IoIs, held on that Node

Commitment	The fact of an Issuer having made a Conditional or Unconditional Pledge of a future Flow of Tokens to a Recipient
Condition	A prerequisite for the Self-Execution of a Smart Token, coded onto the Smart Token itself. Alongside a date or date range (where one is specified), the Trigger for self-actuation of the Smart Token
Conditional	Describing a Pledge on a Smart Token which has one or more Conditions (in addition to any date specified) that must be satisfied before the Smart Token can Self-Execute. There is a risk that Conditional Flows will not be Triggered
Constraint	A limitation or compliance restriction on the execution, Fractionalisation or sale of a Smart Token, encoded onto the Smart Token itself and Self-Executed
Crypto Asset / Currency	Digital asset or cash Tokens whose value is wholly independent of any Off-Ledger reference asset or currency
Decentralised	The attribute of a platform which allows participants to interact and control transactions directly, without the intermediation of central controlling entities, without centralised record-keeping, and without central entities maintaining data on behalf of those participants[2]

[1] See: https://gbbcouncil.org/wp-content/uploads/2021/11/GBBC-GSMI-2.0-Report-1.pdf

[2] GBBC-GSMI 2.0 defines a 'Decentralised System' as a Distributed system wherein control of the system is distributed among the participating entities.

Digital Asset / Cash	An entitlement Issued as a Token or Cluster of Tokens only On-Ledger (i.e. that does not exist in the conventional registry / banking / custody / depository world), and transacted and settled only On-Ledger (i.e. that is not settled through conventional payment and delivery rails)
Digital Custody	The protection of digital client funds or securities, or the authority to obtain possession of them. As it relates to crypto assets, custody commonly refers to holding a client's private keys
Distributed Ledger	A decentralised platform which allows multiple Participants to share the same data, and aligns it in real-time, without messaging or reconciliation. Frequently paired with Blockchain data to enable Participants to trust that transaction data is secure and immutable, and that what they see is exactly what their counterparties see[3]
Flow	The movement of Tokens from one Node to another, or from one address to another
Fraction	A Token created by splitting a Token which Commits a larger Flow
Fungible Token	A Token that is interchangeable with an identical Token in part or in Fractions.
Indication of Interest (IoI)	A Smart Token or cluster of Smart Tokens, left visible on the Issuer's Node, showing what the Issuer is prepared to Pledge: used to show interest in a transaction, and to invite responses from counterparties

Intermediary	An entity that is interposed between the two primary parties in a transaction, and carries out an ancillary role in the transaction process
IOU	A metaphor for a Smart Token, as the Token behaves like an IOU – it is given to the Recipient by the Issuer, and held by the Recipient until the Issuer discharges their Commitment, then handed back
Issuer	The creator of a Pledge, the minter / editor of the Smart Token onto which the Pledge is encoded, and the provider of the Tokens Committed in the Pledge to the Recipient
Label	In the context of this paper, a name allocated to a cluster of Tokens. The nearest thing we have in the Smart Token model to the name of an asset or asset type
Liquidity Provider	A service provider to the Token network, operating a special-purpose Node, and advancing cash and / or asset Tokens to its clients, to enable leverage or to underwrite settlement
Net Settlement	The coordinated transfer of Tokens, based on the Self-Execution of multiple Smart Tokens Triggered within a defined time period
Node	For the purposes of this paper, a location on a Distributed Ledger network at which tokens are held; in other exemplar networks, an address associating a Token with the identity of its owner
Non-Fungible Token (NFT)	A Token that, as a result of carrying unique identification codes and data that distinguish it from all other Tokens, it is not interchangeable with any other Token in part or in Fractions

[3] GBBC-GSMI 2.0 defines 'Distributed Ledger Technology' as a system of electronic records that enables independent entities to establish a consensus around a shared ledger without relying on a central authority to provide or authenticate the authoritative version of the records.

Off-Ledger / On-Ledger	Existing outside / inside the environment of a Distributed Ledger. Generally applied to data, values, assets or cash
Oracle	A service that provides Off-Ledger data to a Distributed Ledger. In the context of this paper, a special-purpose Node, operated by a service provider, which provides Off-Ledger data required by Smart Tokens to evaluate their Terms, such as prices, rates and default frequencies
Participant	The owner of a Node or Address, where they can receive and hold Tokens, and where they can issue, edit and transmit Smart Tokens
Pledge	A Conditional or Unconditional promise from an Issuer to a Recipient to empower a future Flow of Tokens from the former to the latter
Recipient	The receiver and holder of a Pledge from an Issuer, coded onto a Smart Token. The same as a Beneficiary
Self-Actuation	The act of a Smart Token going from an inactive to an active state as a result of a Trigger, such that it commences Self-Execution
Self-Execution	The act of a Smart Token running its own code, evaluating its own Terms, and applying its own constraints automatically, without any involvement from its Issuer or Recipient
Settlement Node	A special-purpose Node, to which Triggered Smart Tokens transfer themselves, enabling efficient Flows in a Net Settlement
Signature	Identity data which, when appended to a Smart Token, enables the holder of the Smart Token to identify its issuer and confirm its integrity

Smart Market	In the context of this paper, a special purpose Node which accepts IoIs / Adverts from participating Issuers and Recipients, matches them and creates trades, on an anonymous basis where necessary
Smart Token	A Token onto which Terms, rules and Trigger Conditions can be coded by an Issuer, enabling the Token to self-actuate and self-execute
Stablecoin	A Crypto Asset / Token that aims to maintain a stable value relative to a specified currency, asset, pool of collateral or basket of assets
Terms	The functions and data which enable a Smart Token to compute the number of Tokens to be transferred from the Issuer to the Recipient of a Flow when it is Triggered
Token	Either a digital Label for title to an asset or pool of cash (like a ticket exchanged for a coat in a cloakroom), a digital coin, or a self-executing (smart) digital asset, committing an Issuer to a future Flow of Tokens
Trade	A transaction in which parties agree to the immediate or future exchange of Tokens in a Bidirectional Flow
Trigger	The combination of a date (or date range) and a set of Conditions, that specify when a Smart Token will self-actuate (i.e. when it will wake up and Self-Execute)
Unconditional	Describing a Pledge on a Smart Token which has a date specified, at which the Smart Token will Self-Actuate, but no other Conditions. There is no risk that an Unconditional Flow will not be Triggered
Uni-Directional Flow	A single Flow of Tokens from an Issuer to a Recipient, without any requirement for a simultaneous Flow in the opposite direction

The Structure of the Paper

This first part of this paper describes the problem with our current view of transactions, suggests an approach to upgrade it, and shows how we can spread the benefit of that change broadly and cheaply through tokens and fractionalisation. It then demonstrates how distributed ledgers can help us to achieve this. The second part, on digital issuance of assets, sets out the radical potential of smart tokens to create a transformative digital operating model for financial assets, and the dramatic impacts that would follow.

What We Can Achieve If We Get Digital Issuance Right

This paper demonstrates how an optimised standard for the issuance of digital assets would deliver dramatic benefits to manufacturers of financial products, to the investor experience, to the ease of regulation, and to the economics of investment. It is within our reach to deliver new and much more flexible products, while simultaneously achieving a profound reduction in complexity, risk and regulation, leading to materially lower costs for all market participants. Investors can have more choice of product, and better access to assets that suit their needs; at the same time, issuers can issue more granular assets that better fit the profile of their funding requirements, and which can be issued more quickly and with more personalisation.

Operationally, if we can achieve a consistent form of representation for digital assets, then we can implement a single operating model across asset classes. All digital assets can be processed in the same way, and the boundaries between asset classes can dissolve: creating new products and asset types becomes straightforward, without operational or technological complexity. As a result, regulation can be made more effective, while being radically simplified through the elimination of redundant processes and roles. System architecture can become simpler and more standardised, making change easier and cheaper, while the requirement for service provision diminishes. Liquidity, trading and liability matching can improve, while security data maintenance, asset-servicing and settlement management shrink, and could evaporate over time.

What Digital Issuance, Digital Assets and Digital Transactions Mean

Because assets are generally represented already on computer systems, there is often confusion about what digital assets are, and how they are distinguished from conventional assets represented digitally. Digital assets are issued only as tokens onto a shared digital network (or 'ledger'), and do not exist in the current registry / custody / depository world[4]. Digital transactions are traded, managed and settled by token-transfer on the digital ledger[5], rather than through physical movements of assets and cash, or through conventional book-entry deliveries and payments between bank / custodian accounts. The paper contracts which define the terms of transactions in conventional assets are rationalised and automated in digital assets: necessary terms are embedded in the digital assets themselves, and processed automatically as part of their life-cycle management, wholly on-ledger.

[4] I am grateful to a reviewer, Martim Norton dos Reis, for pointing out that digital records could be shadowed in the records of custodians, banks and depositories, if we really wanted to, but that this would miss the point of digitisation, and dilute its value.

[5] We will refer to assets, transactions and anything else managed exclusively within the shared digital network as being 'on-ledger'. Anything outside this environment we call 'off-ledger'.

Why We Need an Optimal Model for Digital Issuance

Digitisation offers us the opportunity to achieve a step-change in both the cost and the accessibility of investment. To exploit this opportunity, we need to ensure that we get the implementation of digital right: this means having an optimal model for digital assets, for the form of digital issuance and for the processing of digital transactions.

In isolated cases, but increasingly, assets are already being issued in a digital format, and digital custody is becoming accessible[6]. It now seems inevitable the Central Banks will soon begin to issue cash in a purely digital form too[7]. The issuance of fiat currencies in the form of digital cash will accelerate and catalyse the issuance of digital assets, as we will be able to trade legal tender for assets in a purely digital, and highly efficient form.

What Will Happen If We Do Nothing?

While it is a positive step that assets are being issued digitally, there is no standard approach to this. Diverse issuance models are deployed, and it is inevitable that approaches will become more diverse over time as wider asset types are addressed. This will lead to multiple, isolated ledgers carrying subsets of assets, with diverse issuance models, supported by diverse operations. Doing nothing risks landing us back in a fragmented, inaccessible and unnecessarily costly world.

Regulation of digital issuance is currently somewhere between embryonic and immature. Current initiatives in digital issuance are governed largely by existing regulations, drawn up for a very different context[8]. To be acceptable in current regulatory regimes, digital assets essentially have to behave as conventional assets behave, have to be managed by the same entities as manage conventional assets (who have to carry out the same roles), and have to conform to the same rules. To make it practical for regulators to frame effective rules for digital assets, there needs to be a coherent, optimal and generalised model for digital issuance. Doing nothing risks missing the opportunity presented by digital, because regulation won't let us take it.

The ability to manage investor outcomes could be taken away from organised finance if we do not produce a coherent industry approach to digitisation. Defi[9], while by no means fully proven or universally accessible, provides an increasingly accessible and sophisticated environment in which consumers can manage their own digital affairs. The rise of NFTs and the growing market engagement with crypto show that investors are increasingly prepared to back assets which are not underpinned by conventional value. Doing nothing risks losing control of client outcomes altogether.

Who Really Matters in Investment?

There are only two parties whose participation justifies the existence of the financial markets. These are the asset owners[10], who want to invest money, and the capital issuers[11], who want to raise money, and need access to investment. Size is irrelevant: either may be as big as a nation or as small as an individual investor or borrower. Everyone else in the process is there just as an intermediary, and their role (and cost) is only justified if they make transactions between the asset owner and the capital issuer easier, cheaper, safer, and (in the case of the regulators) fairer. Ideally the two significant parties would interact directly, and with the least possible friction.

[6] Digital bonds and commercial paper are probably the most common assets. Digital custody focuses particularly on private key management and custody of cryptocurrencies /cryptoassets.

[7] China already does, and Sweden expects to by 2026. There are also the Sand Dollar (Bahamas), DCash (Eastern Caribbean) and E-Naira (Nigeria); otherwise, see: https://www.bis.org/speeches/sp210127.pdf

[8] This is true for many regulators; others have retrofitted digital issuance into existing regulations, or built bespoke regs e.g. Malta.

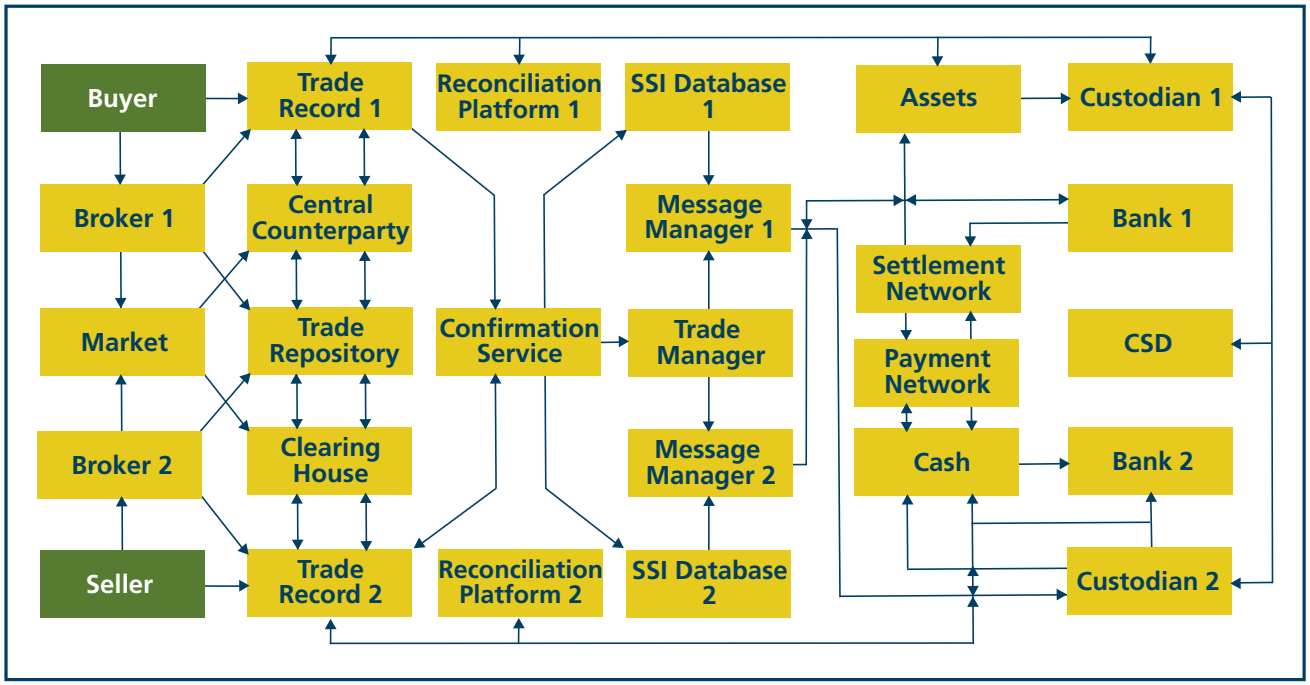
[9] Decentralised Finance. See https://en.wikipedia.org/wiki/Decentralized_finance for a basic explanation.

[10] Asset owners include pension schemes, sovereign wealth funds and individuals with savings. They are often represented by (and confused with) influential agents: these are asset managers (on the asset side) and investment consultants (on the liability side).

[11] Capital issuers include companies borrowing to finance business expansion, and individuals taking on a mortgage to buy a house.

What's Wrong with the Current Model?

While asset classes have different structures and operating models, there is some commonality in the way that we approach the management of transactions. The diagram below is a simplified illustration of the entities and flows involved in a typical transaction of a cash security.



The multiple entities that we have introduced into the process are there to patch over the risks, costs and inefficiencies introduced by our own model of assets, cash and transactions. Each patch has been well-intentioned and implemented more or less effectively. The overall result, however, is a mess. Between the asset owner and the capital issuer, there is a blizzard of intermediary entities and intervening processes, all of which add their own costs and risks. And if this was not bad enough, we then have expansive regulators and expensive regulations because all of this activity, and all of these entities, need to be regulated. We are in a well-intentioned hole of our own making.

Running Out of Road with the Current Model

Our current model of transactions and assets has developed over a long period of time. There has been an extended opportunity to improve it, and many improvements have indeed been implemented; most of these come under three headings.

1. The introduction of intermediaries to mitigate the inherent risk, volume and trust issues introduced by the nature of the current transaction and asset model;
2. The improvement of the processes and technologies deployed by those intermediaries[12]; and
3. The (attempted) reduction of resourcing costs through outsourcing and offshoring[13].

These approaches have delivered a stream of useful improvements in risk, cost and speed, but have now more or less run out of road. If we want to achieve the next step change in benefit to investors and issuers, it won't come from 'more of the same'. Digitisation is not more of the same, and presents us with the opportunity for radical change: if we get the model right.

How Should We Ensure That Digital Transactions Work Better?

To achieve the next step change, we need to replace, not tinker with, the model of assets and transactions that drives current complexity. This paper proposes five fundamental rules for transaction management, targeted to maximise the delivered benefit of digital investment. These are:

1. Have a single transaction record between the parties;
2. Fully immobilise conventional, off-ledger assets and cash[14];
3. Make capture, execution and settlement simultaneous;
4. Going further than (3), make the recording of the transaction and settlement of the transaction the same thing; and
5. Establish trust directly between the trading parties.

If we want a digital revolution, not a digital repetition, then we need to follow these five rules.

An Optimal Model for Digital Issuance of Assets

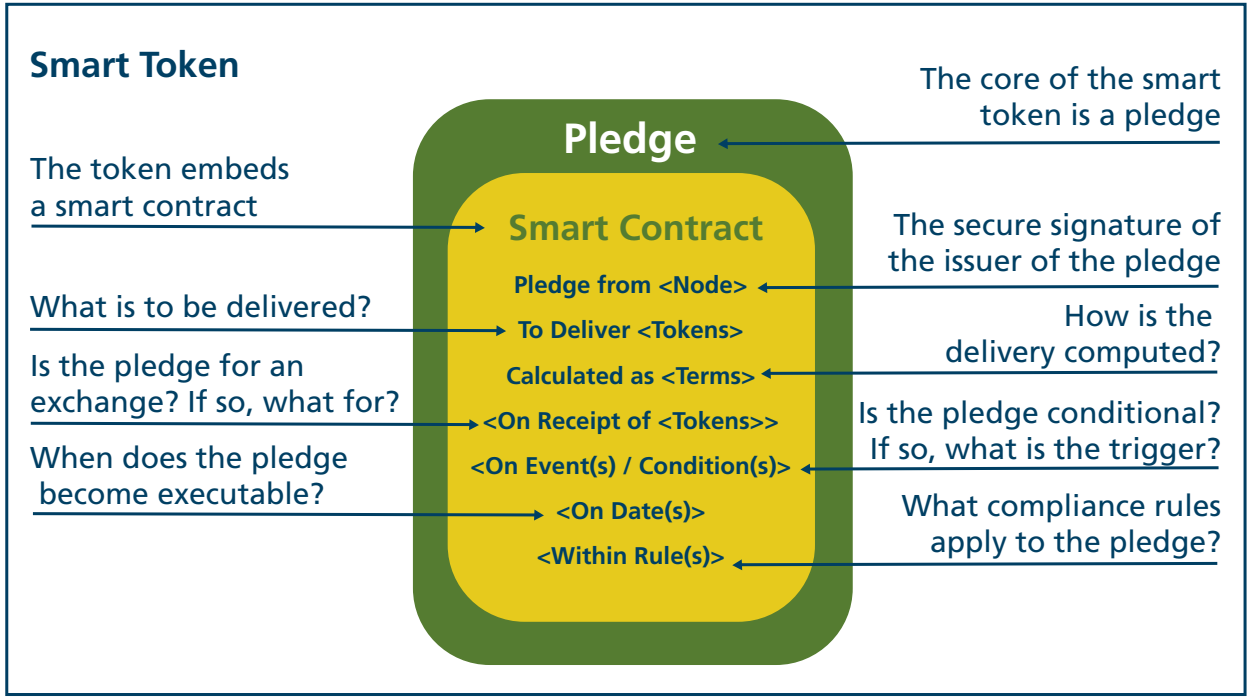
The basic building block of our proposed model is a token that is 'smart', which means that the token itself knows when to initiate its own actions, knows what it can do to itself and to other tokens, and has the ability to self-execute. In the digital world, delivery is not payment or transfer of assets, it is a flow of tokens, and the main capability of smart tokens is to move tokens (including themselves) between nodes. This contrasts with conventional approaches, where the tokens are just data, and intelligence is located within business applications: these operate on and control tokens, which are essentially dumb. In our model the tokens are smart and manage themselves.

[12] Some of these improvements have been made to enable settlement cycles to be shortened for some asset classes.

[13] Offshoring and outsourcing have a mixed track record in cost reduction. Surveys from global custodian banks (in particular from BNYM and State Street) show that many cost-cutting initiatives have fallen short of success.

[14] For all tokenised assets – inevitably there will be a period of migration over which conventional, untokenised assets will not be immobilised.

The standard form of smart token is illustrated below.



Just as for optimal digital transactions, there are five rules for optimal digital issuance:

1. Issue digital assets as clusters of smart tokens pledging future flows of value;
2. Transfer intelligence from business systems onto the tokens: make them smart;
3. Make the smart tokens self-actuating, self-executing and self-controlling, so that their triggers, their capabilities and their constraints are all coded on the tokens;
4. Make the tokens individually tradeable and fractionalisable; and
5. Measure value and risk at the level of the individual tokens, not of the assets.

Representing and issuing assets in this form allows us to build multiple asset classes from the same underlying components, and to transact and process them within the same operating model. Floating rate bonds and deposits, OTC derivatives, pay-downs, callable and amortising instruments are as straightforward to represent and process as a fixed rate bond or deposit. There is nothing special about collateral or securitisation in the smart token model either.

In the proposed model, anything which can exist entirely on-ledger, is represented only on ledger, and in exactly the same way, as a cluster of self-executing smart tokens. The value that they deliver is wholly represented on-ledger too. The only entities which can't be represented wholly digitally are assets which are essentially tangible, like racehorses, office blocks, companies and Picassos. For these assets, we have to use title tokens to represent ownership, although their related income and costs can be represented by smart tokens in the same cluster. That includes equities.

Benefits of the Smart Token Model

The consequences of the smart token model proposed for digital issuance are radical, and hugely beneficial, on both sides of the P&L account. A single, universal model of issuance and transaction can be applied to all asset classes and flows, underpinned by a single operating model that is secure, low-cost, scalable, flexible and transparent. In more detail, the key impacts for investors / asset owners and borrowers / capital issuers include:

- Allowing asset owners and capital issuers to interact freely and directly;
- Much easier and quicker delivery of new and more flexible financial products;
- A wider market of investors and borrowers to sell to, and products to sell;
- A common means of representation across all digital issuance and all digital transactions;

- Radical simplification of the entities and processes engaged in delivering financial products;
- Improved liquidity, alongside more flexible, more granular trading;
- More granular risk management and more realistic valuation of flows;
- Visibility of all assets and liabilities at all times on the same platform;
- More precise matching of assets and liabilities, with a much lower cost of hedging; and
- Elimination of order management as a separate platform.

The benefits of the smart token model, in some cases, apply to service providers, as well as to investors and borrowers; these wider benefits include:

- The opportunity to deliver a new range of services at network level;
- A single operating model across asset classes;
- An order of magnitude reduction in operational costs and complexity;
- Elimination of registry and position maintenance;
- Elimination of settlement management;
- Elimination of income entitlement calculation, payments and reconciliations;
- Radical simplification of corporate actions;
- Radical simplification of cash management and elimination of payments;
- Radically simplified and standardised business system architecture; and
- Elimination of the need for a security master and its associated demands for maintenance and data sourcing.

This is a big list of high value benefits. Together, they more than justify the considerable cost and disruption of a transition to the smart token model for digital issuance.

Conclusion

This paper puts forward a radical model for digital issuance which delivers standardisation of the representation of assets and the management of transactions across asset classes, unlimited trading flexibility for both issuers and investors, and a transformation in the economics of investment.

To deliver this radical model, we need to follow the fundamental rules of digital issuance and transaction set out in the paper. The prize is high: if we follow all of these rules, then we can optimise the benefit of digitisation, and achieve the next step-change in the efficiency and accessibility of investment. We will break down the barriers between instrument classes, and eliminate their bespoke operating models. A wider population will gain access to investment, and a wider set of assets will be investible. Capital issuers will come closer to asset owners, and more flexible, more appropriate investment products will be easier to launch.

If we don't collaborate across industry participants to ensure that these rules (or something like them) are followed, then we risk missing the generational opportunity presented by digitisation. We will end up with a proliferation of approaches to digital issuance, solidifying boundaries between asset classes, and stuck with asset-specific operating models. The current blizzard of intermediaries will remain, as will the cost, complexity and extensive regulation that they entail. In other words, we are quite likely to end up in a digital version of exactly where we are now. And we just might lose the control of client outcomes to Decentralised Finance. That's well worth avoiding.

This paper presents the opportunity of digitisation, shows how and why we should grasp that opportunity, and provides a call to arms to all participants to create the right legacy of digital issuance across financial markets.

The Problem to Solve

Financial products are here to transfer value through time: to take funds available now or soon, and reshape them into flows of value for owners to spend later, when they need them more; conversely, to take funds expected to be available in future and reshape them into flows of value for owners to spend now, or soon, when they need them more. These are two sides of the same coin: one flow one way, one flow the other. One side is the asset side, and the consumers are called 'investors'. The other is the liability side, and the consumers are called 'borrowers'. In between there is a set of service providers and other intermediaries, who should facilitate and smooth the flows.

In this process, the financial markets should make it easier for investors to meet their later obligations (usually by providing investment returns), and for borrowers to meet their nearer obligations (usually by making credit as widely available, and as cheaply available as possible).

The problem is that the financial markets do not do this as efficiently or effectively as they could: investment products are inflexible and insensitive to individual investors' actual need for future flows; access to markets is complex and restrictive; some asset classes are illiquid and hard to invest in; fees mount up because of the large numbers of entities involved in the processing of financial transactions, and operational costs are substantial. So investment is more costly than it should be, and returns are suppressed by the high cost of investment. Access to borrowing is more restricted than it should be and more expensive than we would like.

The results are constraint on capital investment, reduced savings provision, inadequate pensions, and an increased dependence on the state. Our security is damaged and our prosperity diminished, by the very industry which is there to protect our security and enhance our prosperity.

Running Out of Road with the Current Model

Our current model of transactions and assets is mature, to the point where it is increasingly difficult to achieve further material efficiencies or resource savings.

We have, in most material respects, run out of road in tuning and refining the current model of assets and trades: the raw materials of finance. Market participants, including Investment Managers, are under increasing income and cost pressures, that cannot be alleviated by further internal cost-cutting or external outsourcing. If we are to achieve a step change in the cost of investment, then we need to change the model, not just tweak it again.

Digitisation presents us with that opportunity: this paper is a detailed contribution, intended to show what that change might look like, and to demonstrate that it can be achieved through digital technology, supported by cross-industry collaboration, a willingness on the part of participant to adapt their roles, and an evolution of current regulation. If we want to, we can stop damaging our security, and start protecting it; we can stop diminishing our prosperity, and start enhancing it.

The Benefits of Changing the Model - Digital Finance

Digitisation enables a step-change (or more than a step-change) in the cost of investment. This brings with it a series of key challenges about the nature of digital assets, the form of digital issuance, the processing of digital transactions, and the regulation of a digital world.

This paper responds to those challenges. It develops an optimised digital operating model, that is designed to facilitate a step change in the economics of investment. The paper shows how we can deliver new and much more flexible financial products, which better achieve the return and cash flow targets of their consumers; simultaneously, we can achieve an order of magnitude reduction in operational costs and complexity, and reduced operational risks for those who service assets and transactions. The universe of investible assets can widen, and the access to that universe can be democratised, giving us a new and broader market for financial products.

Regulation can be radically simplified too, by eliminating, rather than regulating, processes and entities. We can reduce the current burden of compliance, and mitigate the risk that unregulated forms of digital investment crowd out regulated (and safer) alternatives. Technologically, system architecture can become simpler and more standardised, making change easier to accomplish, while the requirement for expensive technical and operational support diminishes.

Liquidity and liability matching can improve, and trading costs can reduce, while data maintenance, asset-servicing and settlement management costs can shrink, and could even evaporate altogether over time.

Scope of the Proposed Model

The new operating model proposed in this paper accommodates both digital cash and digital assets. It places both within a coherent schema that works across all asset classes and currencies. It offers full value for the substantial effort required to move our management of investment and borrowing into a new form. To achieve all of this, we must harness the potential of digitisation, and the exploit the power of decentralisation[15], to the advantage of the consumers of financial products. The end result is a radical improvement; such radical results require radical means.

What Does 'Digital' Mean?

Digital issuance means issuing assets in purely a digital form, on a shared digital network (or 'ledger') rather than issuing them into the current combination of registrars (to maintain a list of holders of the assets), custodians (to safekeep assets) and central securities depositories (CSDs, to maintain the integrity of the issue and settle transactions by delivery against payment)[16].

Digital transaction means trading and managing transactions purely on a digital ledger[17], rather than through physical or book-entry movements and conventional channels of payment and delivery.

Digital assets may represent an investment vehicle, (such as a fund or wrapper), or may represent underlying securities (such as bonds, equities, deposits or derivatives). In many cases they will be assets in themselves, without any reference to off-ledger entities; as we will see later, these may be the equivalent of familiar asset types, but exist purely on-ledger.

The conventional world surrounds such assets with documentation: generally, these take the form of 'paper contracts', that define their terms and conditions and legal standing. These contracts may be stored digitally, but are an essentially manual construct. The handling and management of manual contracts is still a serious impediment to efficiency for many asset classes. In a digital world, the contracts are digital, and encoded into the asset itself.

So the only record of the asset is a digital representation on-ledger, transactions are all managed on-ledger, and the asset and its surrounding contracts are codified and processed digitally. Normally, the digital form taken is that of a 'token.' The value of tokens usually derives from rights of ownership to a current or future income stream, entitlement to an off-ledger asset that has intrinsic value (such as a gold bar), or a net present value derived from a future stream of income.

Why We Need a Decision on Digital Issuance Now

We are at an important juncture in the development of financial markets, where we need to make some fundamental decisions about the form of digital issuance.

The need for decision is because digital issuance of assets and cash is going to happen. It will be highly disruptive, so we need to design a model that will maximise the benefit to the end consumers of financial products: investors and borrowers. In short, we need a coherent answer to the question: "what is the best form in which we can issue digital assets, that most effectively exploits the potential of digitisation?".

That form of digital issuance needs to be acceptable to the market, and particularly to capital issuers and asset owners. It should be as or more secure than current representations, should facilitate better financial products for consumers, and should enable more efficient and effective regulation. It also needs to be implementable: this means being workable for an extended period alongside conventional assets

[15] In other words, ensure that we take the best ideas from Decentralised Finance.

[16] These three functions are sometimes performed within a single institution, but the tri-partite division of functions is broadly universal.

[17] We will refer to assets, transactions and anything else managed exclusively within the shared digital network as being 'on-ledger'. Anything outside this environment we call 'off-ledger'.

and transactions, and providing choice to investors on whether they access the market by digital or conventional means.

The increasing indigenous issuance of assets on-ledger, in lieu of traditional forms of issuance, is an obvious catalyst. Native on-ledger issuance of assets also demands a model where value is defined entirely in digital terms, rather than as a proxy to an off-ledger entity and an external valuation process. Diverse token issuance initiatives are taking off, and there is an inevitability, rather than a risk, that diverse standards will proliferate: we need to reach a common model of digital issuance[18] before that proliferation becomes endemic.

Having the cash leg of transactions on-ledger is also a critical consideration. Central Bank Digital Currencies (CBDC) are the long-term solution to this need, and central and commercial banks are ever more strongly focused on the digital issuance of cash. They are aware that on-ledger issuance of cash is an essential strategy for remaining relevant: the alternative is a proliferation of private means of exchange[19]. CBDC will be money that is native on-ledger, rather than having its value derived from title to off-ledger cash, which is the basis of most current cash tokens[20]. At that point, we will have both assets and cash in an indigenous digital form on a distributed ledger: native tokens, rather than tokenised cash and assets. Purely digital settlement of purely digital cash and assets becomes both feasible and desirable. CBDC will act as a powerful catalyst for digitisation.

What Happens if We Do Nothing?

A major problem with doing nothing relates to regulation. If regulation is unchanged, unregulated blockchain-based crypto-currencies, NFTs[21] and utility tokens issued into DeFi markets will continue to dominate security and fund tokenisation, and will taint it by association, especially if there are major losses by investors.

In securities and funds markets, doing nothing would also condemn us to apply the same laws and regulations to digital assets and transactions as we do to their conventional equivalents. That would paralyse us before we start moving forward. Do digital assets and cash really have to be just a tokenised form of conventional assets, governed by the same laws and regulations, and managed and transacted in the same manner? It would be convenient for law-makers and regulators, but would be a massive missed opportunity from every other perspective.

There is opportunity cost to consider too. As returns available from conventional assets become more limited, digital assets become more significant as an investment opportunity. If we miss that, then it is likely to lead to the continued growth of unregulated forms of investment that would expose investors to increased risks. Current regulation around crypto, Defis and NFTs is immature; this represents an exposure, at least in the short term, as investors increasingly explore these asset classes.

The case for doing nothing is not strong, and, as this paper demonstrates, the current model is flawed; it is also running out of potential for enhancement. Consequently, we need to take the opportunity to create a model optimised for digital investment, that eliminates those flaws and delivers a step-change improvement. That means exploiting the potential of digital technology to automate far beyond current pre-trade, trade and post-trade processes, and to implement a model that minimises cost and complexity from inception.

[18] A useful example is the joint issuance network being developed by SETL and Digital Asset, with sponsorship from Citibank. See: https://mondovisione.com/media-and-resources/news/setl-and-digital-asset-join-forces-to-create-a-regulated-network-for-tokens-ne/

[19] See the Bank of England's Consultation paper on digital currency – "New Forms of Digital Money" 7th June 2021: https://www.bankofengland.co.uk/paper/2021/new-forms-of-digital-money and the UK Government's subsequent announcement on crypto and stablecoin regulation, 4th April 2022: https://www.gov.uk/government/news/government-sets-out-plan-to-make-uk-a-global-cryptoasset-technology-hub

[20] An interesting perspective on the need for Central Banks to enter the digital currency arena, along with some concerns about CBDC design, is given in the BIS paper: https://www.bis.org/speeches/sp210127.pdf

[21] Non-Fungible Tokens – see explanation on NFTs and crypto in 'Perceptions and Myths on Tokenisation' below.

There is already pressure for, and activity around digital issuance in many asset classes. Separate forms of issuance are being designed on a case-by-case basis, and individual asset types, markets and ledger platforms are going their own way. If we do not fix on a target model of digital issuance which operates efficiently across products and asset types, then we risk creating a chaos of asset-specific processing and platforms, supporting a blizzard of separate operating models, and wasting the investment that is available to innovation. Doing nothing leaves us with all the problems of the current model, plus a chaotic digital environment, plus the difficulty of getting both the digital and the traditional markets to inter-operate efficiently.

Another risk if we do nothing comes from the threat of Defi[22]. If we do not, as an industry, create an efficient and coherent approach to digitisation, then it will become increasingly possible that consumers will do it without us. This is a remote threat currently, but it is rising.

This paper seeks to show to all market participants how re-thinking our view of digital assets and transactions can lead to transformative change in the economics of investment. It examines the raw material of financial products, and asks how they may be best represented in a digital form. Being on the cusp of a decision gives us the opportunity to define a digital issuance model that maximises benefit to the consumers of financial products, rather than just replicating what exists now into a digital context.

The Digital Issuance Paper

This paper is divided into two key parts:

1. Digital Transactions, Tokenisation and Fractionalisation; and
2. Digital Assets, Digital Issuance and the Impact of Smart Tokens

The first part describes the problem with our current view of transactions, suggests an approach to change it, and shows how we can spread the benefit of that change broadly and cheaply through tokens and fractionalisation; it illustrates how distributed ledgers can help us to achieve this. The paper demonstrates that our existing model of assets and transactions is picturesque, but outdated and unfit for purpose in a digital context. It is an unsound allegory of the process our ancestors followed for exchanging goods for gold. Unsurprisingly, keeping such an archaic model of assets and transactions afloat requires increasingly complex patches that are expensive in terms both of risk and of cost.

In the second part, we shift from critical analysis to constructive solution, and propose a better model that applies generally across financial products and transaction types, while avoiding the unintended consequences of our current model. We show that this model is attainable with digital assets, and document its very substantial benefits.

The second part also sets out the radical potential of smart tokens to create a transformative digital operating model for financial assets, and the dramatic benefits that would follow their implementation. This section is the more significant of the two, and sets out principles of digital issuance which are both radical and powerful. It is hard to overstate the potential impact of smart tokens. The central theme of the paper is that smart tokens are a better, more workable alternative to the current model of issuer-defined assets and issuer-managed transactions.

The smart token model replaces the paradigm of 'intelligent platforms plus dumb data' that currently forms the basis both of conventional business systems and the existing DLT paradigm of blockchain technology. Smart tokens offer us intelligent data as well as intelligent code, and that fundamental change facilitates startling benefits.

The focus of both parts of the paper is to define an optimal model for digital issuance and transactions that can serve as a target. The paper is not about the practicalities of implementation, nor about the migration steps or hurdles on the way: that comes later. It is about the target. Once a target model gains consensus, and we know where we are going, then it will make sense to look in more detail at how we get there, asset class by asset class, product by product, and move towards practical realisation.

[22] Decentralised Finance. See https://en.wikipedia.org/wiki/Decentralized_finance for a basic explanation.

1. What's Wrong Now, That We Can Do Better?

We start with a critique of our current transaction model, try to explain why it is like it is, and show that its high cost and complexity are the result of well-intentioned attempts to resolve its inherent weaknesses. We propose rules for the elimination of those weaknesses at source.

Our Current Model of Transactions

The Cost of Investment

It is a common and reasonable complaint that investment is too complex and too expensive. It is complex to get investment money into the market, and often time-consuming to get it out again. It is expensive particularly, but not exclusively, for the smaller investor. The smaller investor also suffers from the indirect penalty of reduced choice, as flexible financial products are too expensive to deliver at small scale. The impact of a radical fall in the cost of investment would be a substantial macro- and micro-economic benefit, contributing not only to the reduction or elimination of pension deficits, and giving investors better returns on their savings, but also increasing the rate of growth of the economy.

This in turn would contribute to the creation of wealth, the mitigation of poverty and a reduction in dependence on the state.

There is already strong downward pressure on fees (and therefore on costs) in the investment industry. It is in the interest of Investment Managers themselves to reduce the cost of investment: high costs dilute investment returns and lead to a consumer perception that managers provide poor value to their clients. Managers are also keen to reduce costs to protect their profitability in an environment of falling fees[23], and the industry generally is exposed to new entrants with radical, low-cost operating models[24].

Cost-efficiency has become a regulatory focus too. In July 2018, the Chairman of the FCA's Institutional Disclosure Working Group, Professor Chris Sier, suggested that the real cost to the investor of an equity ISA may be as much as 3.5% annually. Professor Sier is quoted[25] as saying that the very first investment product he looked at as part of the Working Group was a simple equity ISA. This, according to Sier, had no fewer than sixteen layers of intermediation: "…in other words, 16 companies sitting between you and investing your money. Every one of those companies takes a piece of the pie as it passes through. The total it added up to was over 3.5%". 3.5% in a world of low yields is hugely significant.

The management fees of fund managers are explicit, and subject to downward competitive pressure: fees have generally reduced since the Sier report[26]. They are, however, just one layer of charging among many, and the majority of the costs borne by investors in funds are not readily visible to the client, despite numerous regulatory attempts to bring greater cost transparency. These include transaction charges and commissions, fees paid to administrators and custodians, the cost of margining and collateral, foreign exchange (FX) costs, securities borrowing and lending revenue shares, charges for distribution and advice, and many more.

Sier claimed to have identified several hundred fees and charges that investors pay unwittingly. Of course, the investor is paying for investment expertise and advice, as well as for the infrastructure of distribution, investment and transaction management. Most analyses show that the cost of advice and expertise is a relatively small proportion (maybe 30% or less) of the cost of investment. Arguably, the other 70% or more is overhead and adds little or no value. A Which survey[27] in June 2021 found that the average cost of advice alone, for a £250,000 portfolio, was 5.7% over the first five years, or an annualised 1.14%. This average sat in a range from 0.7% to 1.72%.

[23] Increasing costs of regulation and data management make this challenging. It is not unusual for asset managers to have little or no capacity for change, once they have resourced mandatory regulatory changes.

[24] In addition to threats from passive and Defi investment, there has been much speculation about Amazon, Apple, Facebook and Google entering the asset management arena, e.g. Moody's 'Asset Managers Global 2017 Outlook' 17th November 2017.

[25] Inter alia, BBC Moneybox, 'What is the Impact of Fees and Charges on Long-Term Net Returns?' Robin Powell, Regis Media in AJ Bell Investcentre 18th February 2019

[26] Albeit there are still many specialist funds, hedge funds, PE funds etc. still charging 2% of net assets plus 20% of performance annually.

[27] Which?: 'How Much Financial Advice Costs', June 2021. https://www.which.co.uk/money/investing/financial-advice/how-much-financial-advice-costs-a1dwl4f8j8pf

3.5% as an annual cost of investment is highly significant in absolute as well as relative terms. It reduces the overall return to the investor by 50% over a 20-year investment period. If that cost can be reduced to 1% annually, then the loss becomes less than 20%. Putting that the other way around, the investor's return would be 67% higher with costs of 1% than with costs of 3.5%. If the cost could be reduced to 0.5% annually, then the investor's return would be 84% higher; that would mean the saver retiring on a pension of close to double the value. These are massive impacts that would be transformative for pensions and savings.

The Parties Who Really Matter

While there are many parties drinking at the investment well, there are only two parties who really matter in investment: these are the capital issuers and the asset owners who, respectively, create the ultimate supply and demand for investible assets. The asset owners (whether they are individuals or institutions) need access to appropriate assets, so that they can invest their funds to generate return within their appetite for risk. The capital issuers need access to capital to invest in the profitable opportunities that they have identified, and from which they will pay interest or dividends, and repay the sums raised. Or maybe they are individuals who just want to buy a house.

The asset owners are the investors; the capital issuers are the borrowers. Either may be a country, an institution, a large company or a private individual. Their scale is irrelevant: whoever they are, they are the only ones who really count. Everyone else in the process is just an intermediary, facilitating (or hindering) the interaction between these two primary and essential players.

In an ideal world, the two parties would interact directly, find a perfect match of supply and demand of investible assets, and transact without the need for intermediation. That ideal world may be tough to attain in practice, but it is worth keeping in mind always as the ideal target. It is an Occam's Razor[28] of finance: What can be achieved with less, is achieved in vain with more. The simpler the structure, and the fewer entities intermediating between the players who really matter, the better.

Regulation

Unfortunately, we currently have a model of assets and transactions in which there are multiple intermediaries between issuers and investors, that engage in complex and expensive processes. William of Occam would not approve. Within such a high degree of complexity, the opportunities for malfunction, whether inadvertent or intentional, are profuse. To protect the parties who really matter (and particularly the smaller, individual variety of investors and borrowers), regulation has become a major plank of financial infrastructure; and a major source of cost.

Regulation is evidently necessary within the existing system, but is expensive, onerous, and not always effective. It adds materially to the cost of investment, and consumes resources which could otherwise be invested in innovation, business development and improvements to efficiency.

A good example is Know-Your Client (KYC) and Anti-Money-Laundering (AML), Countering-the-Finance-of-Terrorism (CFT) and sanctions screening. These are forms of financial crime regulation, which impose enormous costs but are arguably almost totally ineffective. Sources differ, but in 2020, LexisNexis estimated compliance costs in 26 markets at US$213.9 billion[29], while a 2018 Refinitiv survey of 19 countries put it at $1.28 trillion[30], or 3.1% of turnover[31]. On the benefit side, they estimate the cost of financial crime itself to be $1.45 trillion[32], and ComplyAdvantage claim that 98.7% of money laundered goes unidentified[33]. So, if these numbers are right, then a compliance cost to the industry of over a trillion dollars generates a 1.3% net result.[34]

[28] William of Occam 1287-1347: "Non sunt multiplicanda entia sine necessitate", which translates as: "Entities are not to be multiplied without necessity". This principle of scientific method is known as "Occam's Razor".

[29] https://risk.lexisnexis.com/global/en/insights-resources/research/

[30] https://www.refinitiv.com/content/dam/marketing/en_us/documents/reports/true-cost-of-financial-crime-global-focus.pdf

[31] https://www.refinitiv.com/en/resources/special-report/global-risk-and-compliance-report

[32] https://www.refinitiv.com/content/dam/marketing/en_us/documents/reports/true-cost-of-financial-crime-global-focus.pdf

[33] https://complyadvantage.com/insights/

[34] It is hard to prove, but the overall return may be negative. It has been suggested by a reviewer, Dominic Hobson, that Digital Identities could be more effective, and (a) catch people inside the system rather than trying to keep them out of it and (b) put the onus on the customer, not on the vendor. The same logic could apply to, say, safekeeping of digital assets, which could be tied to digital identities rather than to private keys. This is an interesting argument, but outside the scope of this paper.

A malign symbiosis has developed between the regulators and the regulated, in which complicated business processes attract regulation, which in turn makes the processes even more complex. The more processes, roles and entities that exist, the more extensive and complex will be the regulations that govern them. Regulations not only govern their targets, but in many cases mandate the existence of those targets as intermediaries, roles and processes. There has to be a depository overseeing service providers to an OEIC; the client money rules dictate a cash payment process; certain derivatives must be settled through a clearing house; securities transactions in Europe must be settled through a CSD; and so on.

It is a statement of the obvious that the recent CSDR regulation, which is consuming time, cost and resource across the financial markets, would be unnecessary if CSDs were not a mandated part of the transaction model. The financial penalties and buy-ins which CSDR prescribes for settlement failure wouldn't be there either.

With a better, more transparent model, with simpler processes and fewer roles and entities, there would be less to regulate, and more chance of regulation being effective. Dial down the complexity of the model, and the costs and intrusion of regulation will retreat commensurately. We need to define and implement that better model, before the current affliction becomes unsustainable.

The Green Agenda

ESG has become a widespread theme in investment; it impacts analytics, product design, portfolio construction and reporting, as well as stimulating a flurry of marketing activity. It is a remarkable force for social responsibility: the fund managers' websites are full of it, regulators are demanding data on it[35], and clients are channeling money into it.

Moving to a better model of assets and transactions will not in itself guarantee better behaviours or environmentally-friendly outcomes. Issuers will still fail, thieves will still target victims, and kilowatts will still be consumed by computers. However, a better model will facilitate a reduction in waste, will deliver better financial products for consumers that will improve their quality of life, and will require simpler infrastructures that will consume less energy. It can be founded on more transparent records and more inherently secure technology that will better protect consumers from attack. It may not deliver green directly, but it is supportive to our becoming more sustainable and more responsible.

Our Outdated View of Assets and Transactions

It is a common, and complacent misconception that we have solved the problem of efficient trading and settlement by dematerialising assets, implementing book-entry transfer, and automating settlements. We no longer have share certificates to shunt around: dematerialisation was done and dusted for equities after Big Bang and into the early nineties, and trade processing was largely sorted in the later nineties and noughties, through straight-through-processing (STP) initiatives. Automation of settlement, by delivery vs payment in central bank money, was effected by the introduction of CSDs, mainly in the 90s. According to this view, we are now just mopping up the more difficult and delinquent asset classes: OTCs and private assets[36] remain a pain with their bespoke terms and heavy paperwork, bearer bonds are tricky, and real estate is worse. But the major asset classes are sorted. Except that they are not.

In practice, we have made a rod for our own backs. The root of the problem with our current model is that we have an outdated and inefficient view of what a transaction is, and what an asset is. This inefficiency drives the need for multiple intermediaries. Indeed, over the last 30 years, what we have really achieved is the automation (or outsourcing / offshoring) of existing processes, and the addition of further services and intermediaries to patch over the undesirable consequences of the current model. This has delivered some costs savings, reduced some timescales and mitigated some operational risks, but the underlying principles of trading and settlement haven't changed

This paper is about redefining those principles, and delivering a model optimised for a digital world, not further automation of a flawed, existing model.

On the asset side, we have dematerialised major asset classes, but we still treat them as if they are goods in a vault. When we transact, we still talk about 'delivery', as if the asset is going to be moved from one physical location to another. We reflect these in movement between different custodian accounts at CSDs, in a charade of physical delivery.

[35] Again, ESG disclosure regulations are currently of questionable value, even if it sourced in the best intentions. The unquestionable factor is the cost of compliance. The benefit is dependent on dubious ESG 'data' and disputed analytics.

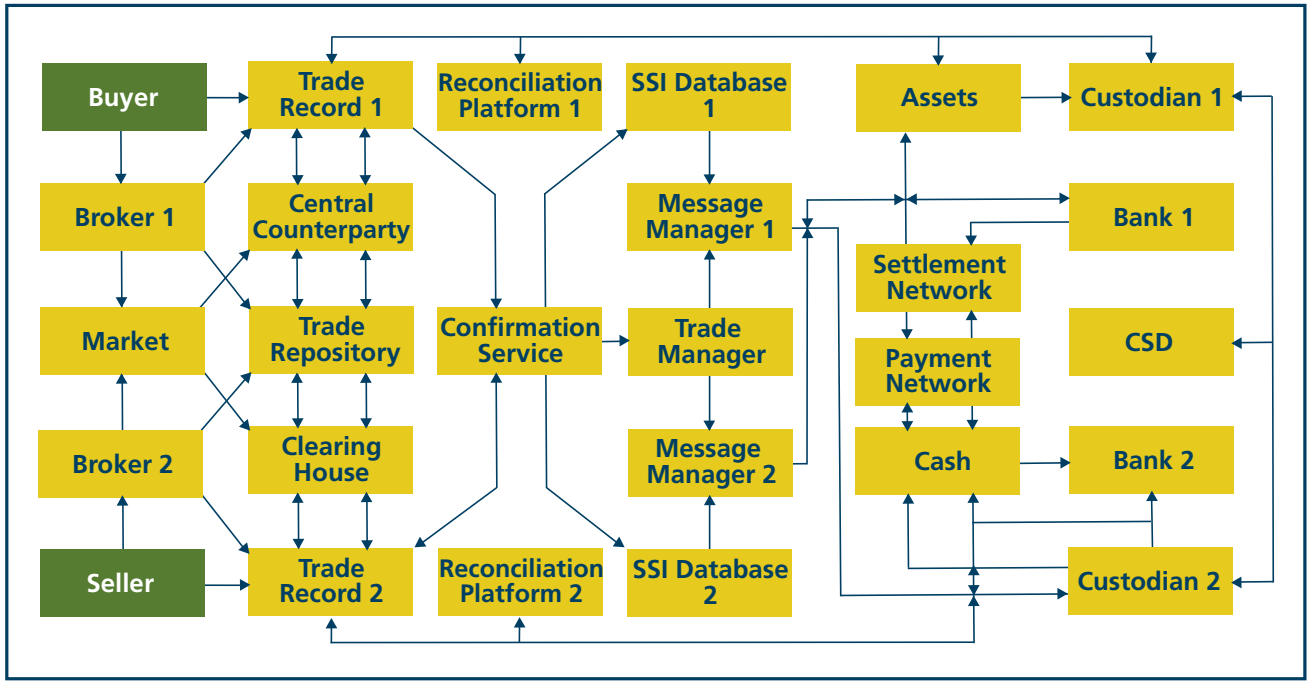
[36] Private assets are both hard to access and complex to process. The search for yield has seen a significant trend from public to private assets, which makes them makes them a particular and increasing problem.

On the cash side of transactions (and assets), we have retained a similarly picturesque and historic view. Cash exists in bank accounts, and is delivered through payment mechanisms between accounts at central banks, or between accounts at commercial banks. It is an allegory of safes, bullion and physical cash movement. Settlement is a process of moving assets one way (from one vault to another) and cash the other way (from one safe to another).

A simplified and generalised schematic of our current transaction model is presented below, to contextualise the argument that follows. For clarity, the diagram includes only entities and relationships: the addition of processes would more accurately represent the complexity of the current model, but the resulting diagram would be too dense to be useful.

When we transact, the buyer and seller reach an agreement to trade, often through their respective brokers. Both sides make a separate record of the agreement, and report the trade to a repository. They plan that the transaction will settle sometime later, when the actual exchange of assets and cash will take place. In the meantime, each party checks that their record of the transaction agrees with the other's, in a confirmation process designed to ensure that no problem or dispute arises at settlement. Each party then tells the other where and how to effect the delivery of the asset and make the cash payment, in a process known as 'settlement instruction'.

Once settlement instructions have been exchanged, the seller mandates their custodian to deliver the asset to the nominated custodian account, and the buyer directs their bank to make the payment to the nominated bank account, both on the agreed settlement date. On settlement, the asset is delivered from the custodian account of the seller to the custodian account of the buyer at the CSD, and the payment is transmitted from the buyer's bank account to the seller's bank account, usually at the central bank.



The transaction is reflected in the records of the relevant CSD. Reconciliation processes generally follow for both transacting parties to ensure that the payment and delivery have completed as expected. Unless the payment or delivery fail, or are not what was expected by either or both parties, then that is "job done".

The Consequences of Our Current Model of Transactions

This is very familiar, and it is easy to believe that it has to be this way. In reality, however, it is an unnecessarily protracted and clumsy process, laden with unforeseen, negative and systemically inefficient consequences.

Because accessing markets and liquidity is not straightforward for most participants, we often trade through broking intermediaries. This gets us access to the technology and connectivity of the broking firms, as well as access to the markets in which they operate. Brokers charge through a spread or commission for finding counterparties for our trades, and for facilitating transactions.

Because the parties to a transaction (generally) do not know each other, and (usually) cannot trust each other, the need arises for central trusted entities to settle the transaction, and ensure good delivery: these are the correspondent bank for the cash and the custodian bank for the assets. At a cost (including the associated due diligence and oversight that has to take place), the involvement of the custodian and the bank gives the transacting parties comfort that a trusted intermediary will effect the transaction as instructed. Both intermediaries make a charge for their services, take time to deliver their functions, and pose entity risk to their clients.

The bank and custodian make book-entries independently on behalf of the actual participants in the trade. They can make whatever book-entries they choose, and we do not oversee them as they do their work, but we trust them to reflect our trades completely, accurately and in a timely fashion. We have to. There are controls, audits and assurance reports[37] which aim to boost our confidence in the integrity of the intermediaries and of their processes. These controls, audits and reports drive significant cost.

Because the time when the transaction takes effect (i.e. the settlement date / time) is after the time when the transaction is agreed and recorded, there is a risk over that period that one or both parties will fail or default, and that settlement will fail as a consequence. One or other party could go bust, have inadequate assets or cash to meet its obligations, or just decide to repudiate the trade. This may cause serious knock-on effects, because the assets or cash may be required by the receiving parties to fund downstream settlements. Settlement failures reverberate through chains of transactions, which also fail. Sorting out the mess adds material cost.

Addressing the problem of counterparty risk is costly to the exposed entity. The problem is addressed in some markets by the regular exchange of collateral. Collateral management involves frequent revaluations, reconciliations and deliveries of collateral assets, all of which carry risk and consume resource. In other markets, counterparty risk is addressed by the introduction of a central counterparty (CCP), against whom all trades are effected by both sides, and who can be trusted to settle the trades as agreed. The central counterparty takes the risk against the trading parties. It charges both parties for taking this risk, and for adding liquidity to the market in order to avoid non-delivery. The costs to participants include the capital that users have to post to multiple CCPs, and capital posted against the risk of the CCP itself failing.

A very large amount of value is locked up in financial assets, and a very large number (and value) of transactions takes place across financial markets. The total global value of equities in 2021 was $105.8 trillion[38], with an average of $700 billion traded daily[39]. The bond market is larger than the equity market, at $123.5 trillion[40]. It is hard to get global values for trading across bonds, but 5 years ago, the bond market was 3.5 times larger than the equity market[41]. Derivatives and collateral are smaller in term of gross value, at $12.6 trillion[42] and $19.8[43] trillion respectively, but their trading is disproportionately higher. Repo alone turns over $3.45 trillion daily[44], or 5 times the value of traded equities. There are a lot of trades.

[37] Like the FRAG (21) report on financial service organisations: FRAG is "Financial Reporting & Auditing Group Guidelines"

[38] https://www.sifma.org/wp-content/uploads/2021/07/CM-Fact-Book-2021-SIFMA.pdf

[39] https://www.statista.com/statistics/242745/volume-of-global-equity-trading/

[40] https://www.sifma.org/wp-content/uploads/2021/07/CM-Fact-Book-2021-SIFMA.pdf

[41] https://www.fool.com/knowledge-center/5-bond-market-facts-you-need-to-know.aspx

[42] https://www.bis.org/publ/otc_hy2111.htm

[43] https://finadium.com/we-size-the-global-collateral-markets-at-19-8-trillion-premium/

[44] https://www.icmagroup.org/Regulatory-Policy-and-Market-Practice/repo-and-collateral-markets/icma-ercc-publications/frequently-asked-questions-on-repo/4-how-big-is-the-repo-market/

Because a very large number of transactions takes place, and each transaction normally generates two movements (in assets and cash), there is a very large volume of payments and deliveries. Each payment and delivery takes time and has a risk of failure. So, to make these as quick and reliable as possible, automated payment networks[45] are introduced, which carry the traffic (more or less) securely and (more or less) guarantee delivery. The payment networks charge for the provision of infrastructure and for the carriage of payments and deliveries.

Even with the payment network in place, there is a high cost and significant operational risk. There is a huge volume and value of movements, and banks remain on risk on them until net amounts settle in the RTGS system[46] of the Central Bank. To reduce these levels, and therefore to reduce risk and cost, and to minimise the funding required from participants to effect settlement, a clearing function is implemented. This nets transactions, and seeks to reduce the actual movements of cash and assets to a practical minimum. These 'clearing houses', which are often aligned with a central counterparty, operate old-fashioned net settlement batch processing infrastructures; they charge for their services and add entity risk[47].

Because both trading parties make their own records of the transaction agreement, there is the risk that the records may be inconsistent, and therefore that the parties may have different expectations of the terms of the transaction. This will lead to disputes at the point of settlement, when (at least) one of the parties receives different cash or assets from what they were expecting. The consequent investigation, and the amendment of the transaction itself, will take time and cost money. To address this risk, a reconciliation matching process is introduced, where the parties compare and align their transaction records. This confirmation process itself adds cost and operational risk to the trading parties, and is often facilitated by a third-party platform[48], which will also charge for the delivery of this service.

Because we need to provide instructions to our counterparties on the custodian and bank accounts to use for settlement, we generate a very large volume of communications, each of which takes time and carries a risk of corruption or failure. To mitigate this, we introduce central databases of standing settlement instructions (SSIs)[49], so that the counterparty can look up the receiver's account details, rather than being sent an instruction for each transaction. The operators of the central databases charge for access to their service. Despite the existence of SSI databases, erroneous SSIs remain a major problem. Catching these errors is a significant feature of the leading transaction management and payment platforms, including SWIFT's prominent gpi system for payments and the DTCC Exception Manager for securities. Automating the status quo is rarely straightforward, and often leads to consequences that need clearing up downstream.

The existence of the settlement instruction databases themselves does not eliminate the need for the counterparties to send the payment / delivery instructions to the custodians and banks who are to effect the deliveries and payments. This generates a high volume of asynchronous messages, and message management platforms are a key component of STP solutions. Cross-border securities trades are also agreed by a message exchange, usually carried by SWIFT. In many investment firms, message management and integration platforms are very material contributors to the complexity and cost of technology.

[45] SWIFT is the obvious example for cross-border payments / deliveries. Its cost to participants was almost €1bn in 2020.

[46] Real Time Gross Settlement.

[47] CLS is a good example as a clearer of FX and some derivatives. Its cost to participants is £215m annually. The real value of the clearing houses (and their related CCPs) is to net the vast transaction volumes so that the banks don't need to fund the gross amount of transactions. Any tokenisation model has to address the benefits as well as the risk and cost of netting (see ''Settlement with Smart Tokens" section below).

[48] Prime examples are DTCC's Omgeo CTM (Central Trade Matching) facility, and IHS Markit's MarkitServ.

[49] SWIFT has one of these, called SWIFTRef; another prime example is DTCC's Omgeo Alert SSI database.

Even having got this far, there is a risk of failed delivery. This may be because of strategic shorting, inadvertent failure to source the required assets, a failed upstream settlement, a deliberate scam or otherwise. In order to protect against such failure, where that is possible at all, then we introduce stock-borrowing and contractual settlement facilities, generally delivered by service providers, who charge in one way or another for these services.

Finally, the agreed, confirmed, instructed, funded trade is ready to settle on the agreed date. The buyer's bank transfers the cash to the seller's bank account, and the seller's custodian delivers the asset to the buyer's custody account. With luck, these events are more or less simultaneous, and do not result in an exposure to the party which delivers first. The bank and the custodian add their own transaction charges.

This apparently ultimate step is not quite the end of the story. Operating behind the settlement, there is a CSD. These new intermediaries were 'reinvented' and made universal in a G30 report of March 1989, following the exposure of weaknesses in settlement and clearing by the 1987 market crash. CSDs were implemented in the 1990s, to prevent double spend, and act as a check that securities held are always equal to securities in issue. They enable immobilisation of dematerialised assets, facilitate DVP settlement to a standard timetable in central bank money, act as a single location of issuance for each security, and provide ultimate assurance of the existence of the assets themselves. They parallel a Central Bank's assurance of the existence and worth of cash.

A CSD effectively intermediates between the issuer and the custodians, who reflect the CSD's holding records in their own books. There is no standardisation of CSD interaction, and global custodians have to maintain interfaces to every CSD that they deal with. Despite the intention to immobilise, we continued, and still continue, to 'deliver' assets between custodians (and cash between payment banks). We have just introduced another intermediary, a few more steps into the process, and some more cost. While CSDs do not add the largest cost margin to the transaction process, as any market participant obliged to comply with CSDR knows, the cost of the CSD's involvement is not always insignificant either.

As a necessary overhead on everything that has been described, there is regulation. The cost and impact of regulation is a function of the number and complexity of the processes which we operate, and the intermediaries that are engaged in those processes. The fact that we have introduced so many intermediaries and processes, to patch over risks inherent in the conventional trading model, means inevitably that the cost of regulation is high. This cost is not just an uptick on the cost of transactions: regulatory changes are mandatory, and consume resources and development budgets across market participants. This constrains the resources and budget available for business development and product enhancement, throttling the delivery of benefit to investors.

It is clear that, with the model of transactions and assets that we conventionally operate, there is the need for a large number of intermediate functions, and for the intermediary entities that deliver them. Each intermediary's role seems to make sense in isolation, and all are introduced with the very best of intentions, to improve the integrity of the transaction process and to reduce risk and cost. However, those risks and costs arise in the first place because of the very nature of the transaction and asset model that we have chosen to deploy.

In summary, conventional approaches to the improvement of the transaction process have three key elements:

1. The introduction of intermediaries to mitigate the inherent risk, volume and trust issues introduced by the nature of the current transaction and asset model;
2. The improvement of the processes and technologies deployed by those intermediaries; and
3. The reduction of resourcing costs through outsourcing and offshoring.

A combination of these three approaches has been successful in achieving stepwise refinements and incremental improvements in trade processing. While they are helpful, sensible and practical in isolation (and in the current context), they are never going to enable efficiencies on an epic scale: transformational change requires a model that does not generate the risks in the first place, and does not ingrain systemic inefficiency in their mitigation. The standard three approaches to process improvement have run their course, and the opportunities for further improvement are drying up. To achieve a step change, we need to change the model.

A Better Model of Transactions

To address these issues systemically requires that we go back to square one, and redefine our view of assets and transactions. Deploying Occam's Razor, we want the least complexity, and the least number of entities, engaged in the process. This means that we should postulate the least number of intermediaries between the ultimate counterparties (and only real players): the asset owner and the capital issuer. The rules are simple:

1. Have a single transaction record between the parties;
2. Immobilise conventional, off-ledger assets and cash;
3. Make capture, execution and settlement simultaneous;
4. Going beyond (3), make the recording of the transaction and the settlement of the transaction the same thing; and
5. Establish trust directly between the trading parties.

In more detail:

1. Have one record of the transaction, not two: share it. Where there is one record, the need for trade messaging reduces, and both confirmation and reconciliation become irrelevant;
2. Stop moving anything around that requires delivery (or payment): immobilise both assets and cash off-ledger, so the only things that move are tokens, transferring between nodes (or addresses) on-ledger. Even though CSDs notionally immobilise assets, we still deliver them between custodian accounts as part of the settlement process. When we stop moving things around off-ledger, then delivery messaging and payment networks become redundant, settlement instructions do not need to be sourced or transmitted, and the rationale for clearing shrinks.
3. Don't leave a gap between agreement, recording, execution and settlement of the transaction: make them simultaneous. When there is no gap, then there is no period of counterparty risk where the settlement may fail because the parties may fail (or renege), so intermediation by central counterparties is not required; neither is collateral or margin.
4. Make the record of the transaction and the settlement of the transaction the same thing. When both the recording of the transaction and the effect of the transaction are digital, rather than physical movements, there is no reason why they can't be identical, as well as simultaneous. When they are identical and simultaneous[51], then a source of operational risk is eliminated, settlement disputes are avoided and reconciliations evaporate.
5. Find a way for the parties to trust each other – at least to the point of knowing that the assets and cash exist, that the other party holds them, that their title is clean and that they cannot use them for any other transaction once the trade is agreed. This eliminates the need for trusted intermediaries to effect settlement.

[51] Fat fingers can remain an issue of a kind, but in a DL transaction, both parties sign the record, so they would both have to agree to the error.

Immobilisation of cash and assets can happen, once we accept that settlement is not a play-act version of swapping goods for gold. In the conventional world, we have dematerialised but not immobilised, while the real benefit comes from immobilisation, not dematerialisation.

The holy grail, in our conventional view of assets and transactions, is delivery against payment. But in a more efficient, digital world, the things we absolutely don't want are delivery and payment: delivery means moving assets between accounts, and payment means moving cash between bank accounts. In the better world that we should be creating, conventional assets and cash will be fully immobilised. That implies that there are no deliveries and no payments, so we don't need the payment systems and networks which carry them, or the netting and clearing mechanisms which reduce their volume. We also eliminate the need to locate and transmit settlement instructions.

Making trade recording and settlement simultaneous removes the period over which settlement risk persists, so we don't need central counterparties or movements of collateral to mitigate that risk. Making the record and the settlement of the transaction the same thing eliminates the risk of mismatch between the expectations of the counterparties and the actual settlement.

When the parties can trust each other to deliver in any transaction, then there is no need for intermediation by trusted third parties to effect settlement; so the role of banks and custodians in settlement is removed[52], along with the requirement for post-settlement reconciliations. Trust is also essential for new participants to be willing to enter the market and transact. For them, transparency is key, as is independent validation of both counterparties and assets.

The fact is that we are a long way from making investment as efficient as it can be. It is clear why there are so many intermediaries, so much cost, risk and delay in transaction processes. The solution is in our hands: it is called 'tokenisation'. We just have to be capable of radical thought, and brave enough to make fundamental change.

[52] Banks / custodians may still provide other services, including liquidity provision (i.e. making cash and / or assets available to participants, on loan). The point is that their role in delivery becomes redundant if there is an alternative, solid way for trading parties to trust each other.

2. Building Blocks - Tokenisation and Fractionalisation

We explain (and try to de-mystify) tokenisation, show how it is helpful in implementing the five rules for efficient transaction, and demonstrate that it widens the scope of investible assets. Fractionalisation is introduced as a low-cost way of enhancing liquidity and democratising access to investment.

The Benefits of Tokenisation and Fractionalisation

Tokenisation Explained

At its simplest level, the token is just a label for title to an asset, like a ticket exchanged for a coat in a cloakroom. Tokens exist in a context where everyone with an interest in a transaction or a position can see the same data at the same time on the same ledger. However, tokenisation can be much more radical than this: it takes the idea of the ownership of an asset, or a fraction of an asset, and moves it towards the more efficient digital world set out so far in this paper.

Ownership of the tokenised asset (and / or the tokenised cash) is defined by the location of the token, and secured by a digital identity / secure signature[53], or by the maintenance of private keys. If you hold the token, you own the asset (or the token is the asset, and you own that). This provides a transparent and secure method to represent and exchange value within a shared set of records. Conventional assets and cash are immobilised, while legal and immediate finality of settlement is achieved without deliveries or payments.

Transactions are implemented through token transfer, so title passes instantly with the token: settlement can be simultaneous with the recording of the trade. The transaction record is the movement of the token, so transaction record-keeping is radically simplified: there is no duplication of trade data records, so there is no need for confirmation or reconciliation between the parties. The movement of the token itself changes the record of ownership, so there is no need for maintenance of a separate shareholder register. The transaction is the same thing as the record of the transaction, and both parties see that identical record. Transactions can therefore be cheaper to agree, to record and to implement.

Trades cannot be effected without the availability of tokens to transfer, so there is no matching up of cash movements to trades, no chasing for late cash payment, and no need for contractual settlement or stock-borrowing mechanisms to facilitate settlement when actual delivery fails or is delayed. If trade participants really want or need to transact without the presence of tokens, they can reach an agreement with another participant[54] to provide the tokens for them. Settlement is still effected by the transfer of tokens, and the tokens have to be there for the trade to happen.

The token does not have to be just a dumb label for an asset. Given the right underlying technology, it can have active components embedded in it, which define how it is to be traded, and what are the rights, obligations and conditions of ownership. Automated processes can ensure that these are adhered to. The second part of this paper will articulate the radical opportunities presented by smart tokens in this form.

Again, given the right technology, the parties to a transaction in a token will have a high degree of visibility of each other, that is not possible in conventional trades: in tokenised markets, there can be real transparency. The parties to a transaction can be assured that the other party owns what they say they own, and that the history of the asset and the cash is secure and immutable. They can be confident that ownership of the asset will be transferred simultaneously and irrevocably, along with title to the proceeds of sale. The parties can therefore trust each other, at least in respect of the things that they need to take on trust in order to de-risk the transaction.

[53] There is much debate about secure signatures, digital identities and private key management, which is beyond the scope of this paper. For our purposes, we need to know that the signer is who they say they are, and the technology needs to provide a robust solution to this.

[54] A liquidity provider, in a tokenised context, provides cash or asset tokens for leverage, or to underwrite settlement, under an agreement with trading participants.

The Geography of Tokens

Tokens are not materialised, but for the purpose of this paper, it is convenient to assume that they exist at a location (or 'node' or 'address'), where a participant manages its business process and keeps its data. The node may be owned by an issuer, an investor (or group of investors), a service provider, a fund or whoever. Similarly, tokens will not be mobile[55], but it is convenient to visualise them as moving between nodes through trading activity. In practice, it is more likely that they will stay where they are, and only their addresses will change.

Token networks are, normally, either 'open' or 'private / permissioned'. Open networks can be accessed by anyone, and all transaction data is shared to all nodes in the network. Trust is established through consensus mechanisms[56] at network level. In a private network, the node owner is allowed into the network once it meets the gating criteria agreed by the participants in the network; this enables a basic level of trust to be established between participants, without a consensus mechanism. Permissioned networks restrict the visibility of transactions to interested parties only.

Private and permissioned network attributes tend to go together, and are generally seen as more appropriate for trading and financial services contexts[57]. A generalisable model in the financial markets has to respect the confidentiality of trades, and give control to the primary participants in a trade to determine who can share the trade data. In this paper, the network is assumed to be private and permissioned, rather than open, so trades (i.e. token movements and / or pledged future movements) are visible to the parties involved in the trade, not to all participants in the network: this is not Bitcoin[58]. Issuance is a key involvement in any token, so, in addition to the direct participants in a trade, issuers will have visibility of their own issued tokens across the network, wherever they are traded or located.

This example context is defined for clarity in this paper; however, the digital issuance of tokens is not restricted to this particular context, and there will be other technologies within which the proposed model would operate successfully. The context defined is consistent with a Corda[59] network, but could be implemented in other technologies, including a relational database, or on Ethereum or Quorum[60]. In the latter DLs, reference to nodes in this paper should be interpreted as meaning addresses, the ownership of a node should be understood to mean the ownership of an address, and the movement of a token should translate to the change of a token's address.

Tokenisation / Fractionalisation of Illiquid and Inaccessible Assets

Tokenisation has something to offer for all asset classes, but the upsides for illiquid classes are very significant, and offer a further layer of benefit. Liquidity improves with tokenisation because tokens can be traded readily in a decentralised secondary market. For inherently illiquid assets (like alternative investments in real estate, classic cars and fine art[61]), this is a really significant change for the better. In their normal state, these illiquid assets are lumpy, indivisible possessions which are hard to price, hard to buy and hard to sell. If you want a work by Leonardo da Vinci, you need a lot of cash and a lot of patience. To buy a fraction of a Leonardo, you could be in business in seconds, and do it with whatever cash you can afford. The same applies if you want to sell: fractionalisation creates an instant market. To the further benefit of the holder, the creation of liquidity has the secondary effect of increasing values, as liquidity attracts its own premium.

[55] i.e. they stay where they are, but their associated address changes.
[56] There are many approaches to consensus, but 'proof of work' and 'proof of stake' algorithms are prominent.
[57] I am grateful to a reviewer, Colin Parry, for pointing out that a drawback of private networks is that non-members wanting to transact on the network need to do so through entities who are members, which introduces a level of intermediation.
[58] Bitcoin operates on the principle of all participants having visibility of all trades – it is 'open' as opposed to 'private' or 'permissioned'.
[59] Corda is the Distributed Ledger, largely targeted on finance applications, developed by R3.
[60] Quorum is a version of Ethereum, developed by JPMorgan, to address privacy issues in Ethereum which limited its applicability in financial applications.
[61] Racehorses have been the subject of shared ownership, but within individualised shareholding structures, subject to company regulation, and not generally tradeable as fractional shares on an open market. As it happens, many funds are not tradeable in a secondary market either, and have to be redeemed with the fund.

The lumpiness, indivisibility and high cost of many illiquid assets puts them well beyond the reach of the ordinary investor (or enthusiast). You buy all of your target asset, or none at all. If your target asset is a commercial building or a Silver Ghost, then the barrier to entry is high: most ordinary citizens are therefore excluded from these markets. Fractionalisation delivers accessibility, and enables even smaller investor to own a portfolio of art, fine wine and country estates: it democratises investment. Democratisation brings with it the prospect of micro-holdings and trades, which highlights the need for very quick and low-cost transaction management: the model, and its underlying technology, must be highly efficient.

The argument for tokenisation of conventional illiquid assets is good, and the prospect of strongly increased liquidity in alternative investments is real[62]. But outside the realm of conventional assets, there is an extensive set of other assets and income streams which are potential investible, but which are not conventionally seen as such. They are not traded publicly, and are not included in investment portfolios. These include artists, authors, footballers, pop stars, educational establishments, communities and even social intervention projects[63].

From an investment perspective, these 'inaccessible assets' share a lot of attributes with mainstream investments. A footballer, like a bond or an equity, is an entity with a value that can change, and which generates (and consumes) cash flows over its lifetime. It presents the prospect of return and the reality of risk to investors on both of those parameters: its value can rise or fall and its cash flows can grow or dry up. Currently, inaccessible assets are (more or less) impossible for an investor to buy or sell, and very hard to value[64]. Tokenisation offers a way to bring these assets into the realm of investment, and therefore to broaden the span of what is traded. They can be traded individually, or wrapped in a vehicle[65] which is tokenised, and itself can be fractionalised.

Tokenisation and Fractionalisation – Summary Benefits

Summarising these ideas, the trading and investment benefits of tokenisation and fractionalisation can be grouped under five headings:

1. Efficiency – trading in tokens can be instant, cheap and straightforward, compared to trading in the underlying assets or in corporate shareholdings;
2. Liquidity – tokenisation offers the prospect that previously illiquid and inaccessible assets can become liquid and highly tradeable;
3. Transparency – tokenisation allows us to embed intelligence and immutable history in the token which makes it transparently clear what we can do with it, and what its provenance is;
4. Democratisation – tokenisation and fractionalisation remove high barriers to entry, and open up investment to a much broader range of investors;
5. Investability – tokenisation and fractionalisation can broaden the scope of investible assets and open investment opportunities in new types of asset.

In addition to these trading and investment benefits, it is arguable that the transparency of tokenised assets makes continuous scrutiny more practical, regulation easier to enforce and auditing more straightforward.

[62] A study by Jansen and Werker in 2018 found an annual average (il)liquidity premium of 45 basis points for private equity, 65 basis points for real estate, 30 basis points for corporate bonds and 40 basis points for stocks. See https://www.netspar.nl/assets/uploads/P20190321_DP16.pdf

[63] Trading in fractionalised, unconventional assets should be distinguished from the purchase of Non-Fungible Tokens (NFTs), representing an image or artefact associated with the source entity. NFTs are objects in themselves, and have their own value, enhanced by their ability to enforce uniqueness: they do not entitle the owner to a fraction of the asset itself, nor to a share in its flows of revenue.

[64] The Football Index app does provide a venue for speculation on the values of footballers, but this is a shadow market that does not trade the asset him/herself, nor does it allow the asset to securitise itself. Footballers are traded all the time in the transfer market, which is private and opaque; however, there is a token project that aims to "democratise" investment in football transfers by tokenisation. See https://tokenchampions.com/project

[65] Such a vehicle could be a conventional, but tokenised fund structure, or could be a more innovative digital collective product.

Fractionalisation vs Shares and Funds

We already have forms of fractionalised ownership available to investors, so the idea is not wholly new. A share in a company delivers a fractionalisation of ownership of that company. A mutual fund is a form of fractional ownership, as is a unit trust, an ETF and an investment trust (or any other collective investment scheme).

However, shares are limited to those companies that have shares in issue, and this limits access to non-corporate, illiquid and unconventional assets. Access to exchange-traded shares is not always straightforward for the ordinary citizen either, with multiple intermediaries adding cost and complexity to the process of buying and selling, and heavy legal requirements on share issuance. Trading shares off-exchange is a risky process that deters many investors. Tokens can be bought and sold between peers without the weight of this legal and operational infrastructure.

Collective investment schemes have large numbers of intermediaries, including Authorised Corporate Directors, Transfer Agents, Custodians, Depositories, Fund Accountants, Fund Administrators, Fund Managers, Wealth Managers, Platforms and Distributors. This adds up to a high cost of ownership to the investor: as Professor Sier observed above, even a simple equity ISA can have 16 intermediating parties that, in his example quoted above, consume up to 3.5% of the annual return. There is little or no flexibility over the assets too: they are selected by the fund manager (or track an index in a typical ETF). Every investor (more or less) gets a share of the same pool of assets, chosen by someone else. Rights of ownership over ancillary sources of income (such as securities lending) can also be truncated.

With fractional ownership, the investor has the opportunity to build a diversified portfolio of tangible and intangible assets, that are bespoke to the client, and with a lower cost of investment. The fractions can be further subdivided without restriction, so there is no lower limit on the size of investment. This makes it more attractive to smaller investors to take direct holdings efficiently, whereas they are currently limited to buying holdings in expensive and rigid collective vehicles. Tokenisation is a key enabler of fractionalisation at dramatically greater scale and efficiency than conventional structures allow, so tokenisation and fractionalisation are natural bedfellows.

There is no suggestion here that fractional ownership will replace all conventional shareholdings, eliminate funds, or make asset managers redundant. Not everyone wants to make micro-investments or to manage their own portfolio, and many will see value in the services of an investment manager. However, there will be a shift in power and a broadening of investment products: managers will become more accountable for the success of their strategies and easier to replace; the existence of liquid digital assets will facilitate more automated and personalised portfolio management, and at an affordable cost. In any case, fractionalisation offers a very attractive broadening of the investment universe, and will be a better path for some assets than the conventional shareholding and fund structures that we are familiar with.

Perceptions and Myths on Tokenisation

Market Perceptions on Tokenisation

Tokenisation is not a technologist's pipe-dream. It is real, has support from broad sections of the financial community, and there is an emerging consensus on its potential. An article from Deloitte in Luxembourg[66] highlights the upsides of tokenisation consistently with the facts outlined in this paper and with the summary of benefits above. It goes on to summarise the impact of tokenisation on financial markets, saying: "From art to buildings, the way we invest in assets could be about to change fundamentally, with the arrival of tokenisation. The act of tokenising threatens to disrupt many industries, in particular the financial industry, and those who are not prepared risk being left behind."

The Deloitte paper speaks of "unlocking trillions of Euros in currently illiquid assets and vastly increasing the volume of trades". So tokenisation can expand the universe of investment, by widening the scope of what we can invest in, while democratising the universe of investment, by broadening the population who can invest in it.

[66] The Tokenisation of Assets is Disrupting the Financial Industry: Are You Ready? Patrick Laurent, Thibault Chollet, Michael Burke, Tobias Seers. Deloitte Inside Issue 19 – November 2018 https://www2.deloitte.com/global/en/pages/about-deloitte/articles/gx-inside-issue19.html

From a legal and regulatory perspective, there are challenges in moving away from conventional views of assets and transactions. However, fractionalisation has piqued interest across asset classes, so investigations are underway into its legal and regulatory implications in multiple jurisdictions and business contexts.

The art world is an example. At the end of 2019, the Journal of the Center for Art Law published an article specifically investigating the impact of fractional ownership on art. The author, Sophie Chung[67], wrote: "Buying blue-chip art that can return economic benefits requires a significant amount of information such as provenance, artist's background, or potential appreciation. As a result, only limited investors with professional art advice could access that information. Meanwhile, multiple buyers in the 2018 sale of Andy Warhol's '14 Small Electric Chairs' became joint owners of the famous artwork." She cites the significant number of platforms[68] now available which enable investors to gain access to art, describing them as "platforms to sell fractional ownership of artworks [with] missions to provide more people with opportunities to invest in fine arts easily".

The sphere of private assets is of growing interest to investors, and here too, tokenisation and fractionalisation have generated deepening interest. A paper written jointly by EY and R3, in mid-2019[69] explains: "Tokens can be held in wallets on smartphones and sent frictionlessly to other investors, and traded on exchanges. This is a huge improvement to private markets today where assets exist as pdf files, which are complicated to split and re-sell". The paper goes on to conclude that "…now there are ways of cheapening the process and making the investor and issuer experience richer and better in the private markets. Once the processes become standardised and generally accepted, tokenised assets…offer the potential to open up a whole new world of opportunities."

Demystifying Tokens and Tokenisation

We hear about different kinds of tokens, and commonly there is confusion between them. The most common misconception is that all tokens are 'crypto', and somehow shady[70]. A token is just a secure identifier which exists on a network and can be moved around between locations (i.e. nodes or addresses) on its network. However, not all tokens are born equal. The basic parameters of tokens are simple: they are either fungible or non-fungible; they either represent an off-ledger asset or exist only on-ledger; and they either represent cash or non-cash assets.

A token is fungible, if it is like coins within the same currency, in which case any token is as good as any other of the same kind, from a trading perspective. A token is non-fungible, if it is like a unique work of art, in which case it is itself unique and cannot be exchanged like-for-like[71].

If a token represents an off-ledger asset, then it is a marker of title, like the cloakroom ticket, which proves full or fractional ownership of some real-world entity. Those real-world entities may be physical objects, like a horse, a Picasso or a pile of cash, or non-physical bodies, like a company, a fund or money in a bank account. Alternatively, a token may have no reference to an off-ledger entity at all, in which case its entire value is inherent to itself. The issuance of tokens needs close control, as there is a risk to the holder of dilution if the issuer creates excess tokens in the same asset or coin.

[67] Fractionalised Art Ownership & Securities Law. Sophie Chung, Center for Art Law, November 19 2019

[68] The author cites Artfintech.one ("creating a holistic ecosystem for digital art"), ArtSquare ("the new art market, for everyone"), Artopolie ("turns art into fractional shares"), Feral Horses ("own shares of museum-worthy artworks"), Look Lateral ("redefining how art is bought, sold and authenticated worldwide, to enable more universal participation in the global art market"), Maecenas ("Tokenized art on the blockchain") and Masterworks ("Investing in paintings by the best-selling artists of all time"). Conventional art investment funds do exist, such as Artsgain (https://www.artsgain.com/en/) but have high entry thresholds (€10,000), no secondary market, and long lock-up periods. It can be argued NFTs are pioneering art tokenisation (see Damien Hirst reference below).

[69] Asset Fractionalisation—What, Why, and the Future. Lewis and Wightman R3 / EY 23rd July 2019

[70] Refer "Know your cryptocurrency lingo - Crypto coins and tokens are not the same thing" - Business Insider Dec 2021: https://www.businessinsider.in/investment/news/difference-between-cryptocurrency-coins-and-tokens/articleshow/86552746.cms

[71] Damien Hirst has sold 9,000 of 10,000 unique, hand-painted, dot-covered works on paper at a price of US$2,000 each. He has given buyers 12 months to decide if they wish to take ownership of the physical work or own the NFT instead. If they choose the NFT, the physical work will be destroyed. Secondary market trades have raised the total market value of the Hirst collection to more than US$500 million.

Non-cash tokens are most frequently used to represent off-ledger assets; the notable exceptions are Non-Fungible Tokens[72] (NFTs) which are in high current vogue, and which, as well as being non-fungible, are on-ledger asset tokens. NFTs exploit the immutability of blockchain data to create unique digital assets: they are assets in themselves. Frequently the tokens carry a digital image of a work of art, or a celebrity, with guaranteed authenticity, and guaranteed scarcity. They therefore acquire value as digital collectors' items. NFTs are an interesting and rapidly growing phenomenon: they show how digital assets can take off quickly, and capture the imagination of investors[73]. This paper is not about NFTs, but their success does add colour to the central themes of this paper.

There are three currently prominent kinds of cash token – often called 'coins':

- Cryptocurrencies;
- Central (or Commercial) Bank Digital Currencies (CBDC)[74]; and
- Stablecoins.

Currencies have three purposes:[75] they are units of account, stores of value and means of payment. Tokens like Bitcoin and Ether take the form of 'cryptocurrencies': they are currencies in that they are stores of value, but are 'crypto' because they are independent of any real-world asset or currency, and are neither issued nor managed by a central or commercial bank. Cryptocurrencies are also a means of payment in some cases[76], but currently make poor units of account, as their volatility makes them unsuited to measurements of the value of assets. Crypto tokens are fungible (within the same coin) on-ledger cash tokens. There are lots of cryptocurrencies out there right now.

CBDC is widely discussed, but not yet widely issued outside China[77]: its arrival elsewhere is keenly anticipated. It is a token form of cash, but is not tokenised cash: it is cash. CBDC is cash, not least in the sense that it is central bank money; previously, notes and coins were the only way that non-banks could access central bank money. CBDC is cash that just happens to be issued on-ledger, rather than as the cash in your pocket. Commercial banks can issue digital cash on-ledger too, backed by their balance sheets (i.e. their loan books), exactly as commercial banks now issue other forms of currency, backed by their balance sheets. CBDC tokens are fungible (within the same currency), on-ledger cash tokens.

Stablecoins come somewhere between CBDC and crypto, and there is a variety in current issuance[78], among which Tether, USD Coin and BinanceUSD are prominent. Stablecoins are currencies in their own right, but stabilised (i.e. made less volatile than crypto) by linkage to a conventional currency, to a pool of assets, or to a supply algorithm. In their simplest form they may be fully collateralised by an off-ledger pool of cash, to the exact value of the tokens issued on ledger. So holders of the tokens on-ledger may have title to a fragment of a fiat currency cash pool off-ledger. There are more sophisticated approaches, for example the tethering of a stablecoin to a basket of high-quality liquid assets which are cash-like in their behaviour. Some more hawkish stablecoins even tether to cryptocurrencies, while others manage the availability of coins to achieve stability through supply and demand.

[72] For a fuller explanation of NFTs, see: "NFTs explained: Why people spends millions of dollars on JPEGs" - Cnet Jan 2022: https://www.cnet.com/news/nfts-explained-why-people-spends-millions-of-dollars-on-jpegs/

[73] Despite their widespread image as over-valued curiosities, there are many strengths in NFTs. They are unique, purely available in digital form, and their ownership is proved immutably in the blockchain. They are readily transferable, protect royalties for their creators, and offer valuable income streams to, for example, galleries and museums, without their losing property rights in their physical assets. There's a lot of good in NFTs.

[74] See https://www.bankofengland.co.uk/paper/2021/new-forms-of-digital-money

[75] According to the Bank of England in the above referenced consultation paper

[76] Tesla famously accepted Bitcoin for its cars for a period, and still accepts Dogecoin for merchandise

[77] The Bahamas, the Eastern Caribbean Central Bank (ECCB) and the Central Bank of Nigeria have also issued CBDCs

[78] See: "Top 6 stablecoins in the crypto market — what are they, how they work and why they have governments worried" – Business Insider Dec 2021: https://www.businessinsider.in/investment/news/top-6-stablecoins-in-the-crypto-market-what-are-they-how-to-they-work-and-why-they-have-governments-worried/articleshow/87667452.cms

Stablecoins are fungible (within the same coin) cash tokens, normally referencing off-ledger assets. Issuance of stablecoins, like issuance of title tokens to off-ledger assets, needs to be closely tied to the movements in and out of their reference assets / collateral pools. Depending on their approach to stabilisation, stablecoins are more or less stable, more or less simple, and more or less secure.

The dominant types of cash token currently in issue are:

- Crypto currencies; and
- Stablecoins.

They are often traded together, with stablecoins acting as the base currency for trading crypto-currencies such as Bitcoin and Ether.

The currently dominant asset token types in issue are:

- Asset title tokens referencing off-ledger assets; and
- NFTs.

In addition, there are multiple utility tokens which are issued only within, and are specific to individual DL platforms[79].

As we will see later in this paper, this balance will change: the future lies with purely on-ledger digital assets and digital currency, predominantly in the form of CBDC. Asset tokens referencing off-ledger assets will persist, but will only be deployed where this is the only logical alternative. Crypto, NFTs and stablecoins will persist and mature too. They are significant digital phenomena in their own right, have given exposure and a proving ground for blockchain technology (and have received plenty of mainstream press coverage), but are not the central focus of this paper.

[79] Similar to crypto, but local to a ledger, rather than trying to be a wider currency. This is where the boundary between cash and assets becomes blurred, as local tokens may have a value of some kind in future cash. For example, the 180 token in the 180 Protocol. See: https://180protocol.com/token/

3. Underpinning Technology - Distributed Ledgers

Distributed ledgers (and data in a blockchain) are not necessary to achieve the objectives set out in this paper, but they are a useful and efficient way of delivering them. In the right context they are secure, practical and respectable. Blockchain is not synonymous with crypto-currencies such as Bitcoin.

How Distributed Ledgers Can Facilitate Change

Rethinking the way that we record and settle transactions is a good thing, which can lead to the optimisation of transaction efficiency and a materially lower cost of investment. Fractionalisation and tokenisation of assets is a good thing, offers very significant efficiency gains, can lead to democratisation of asset ownership, and dramatically improves liquidity. So far in this paper we have described these potential benefits, but have not linked them inextricably with Blockchains or Distributed Ledgers ('DLs'). This is because the arguments for fundamental change are sound in themselves, and do not depend on the technology in which they are implemented. Efficient and accessible investment is not just a 'use case' for Blockchain and DL Technology: it has its own justification.

So DLT is not the reason why we need innovation, but it happens to facilitate both efficiency and democratisation, and it is highly supportive to both tokenisation and fractionalisation. As it matures, DLT is becoming the strongest possible catalyst for, and facilitator of transformational change.

Blockchain provides us with a transaction data structure which is highly secure and in which history is strictly immutable. So proof of ownership and provenance are transparent for every transaction, and the parties to a transaction can rely on the ownership claims of their counterparty. DLT ensures that the parties to the transaction will always see exactly the same record at the same time. Together, Blockchain and DLs allow trading parties to trust each other, and they remove the need for trusted third parties to effect settlement.

The near real-time alignment of data guaranteed by DLs delivers an ideal means of sharing a single transaction record. The same inherent facility makes redundant the asynchronous messaging and reconciliations which are currently the means of data alignment between transacting parties. The transaction record is the delivery of title, so the transaction can't be recorded without actually happening. We know the title is good for transfer, because we can trust and trace its provenance.

Smart contracts[80] implemented on DLs can define the active behaviours of tokens, codifying how they are to be traded, and encapsulating the rights, obligations and conditions of ownership. Execution of the smart contracts can enforce adherence to the defined rules[81].

Token exchange is a natural ownership model for DLs: the existence of a token at a node (or address) represents ownership, and token exchange between nodes represents all of transfer of title, the record of the transaction, and the resulting redistribution of ownership.

The conventional assets (or cash) represented by the tokens can be fully immobilised, with delivery and payment replaced by the on-ledger token-transfer.

Increasingly, financial assets will be issued purely on-ledger, and in token form from the outset: they will have no representation in the conventional registry / custody / depositary world. A DL is a natural venue for such purely digital assets. The assets will not just be immobilised, but will be inherently immobile. The same will become true of cash: CBDC will be central bank money issued directly on-ledger. Locking them up in a blockchain, and providing visibility to participants through a distributed ledger, is a powerful and appropriate technology in this context.

[80] Investopedia defines a smart contract as: "a self-executing contract with the terms of the agreement between buyer and seller being directly written into lines of code...The code controls the execution, and transactions are trackable and irreversible. Smart contracts permit trusted transactions and agreements to be carried out among disparate, anonymous parties without the need for a central authority, legal system, or external enforcement mechanism".

[81] There is an opportunity for pre-agreement of token templates by regulators, to enable products to be approved, launched and traded more quickly. The smart contracts allow more efficient scrutiny and reporting for both investors and regulators.

Digitising Transactions - Reprise

In this first section, we have proposed that, to reduce the cost of investment as far as is practical, our digital representation of transactions should follow five rules:

1. Have one shared transaction record, not two;
2. Immobilise conventional, off-ledger assets and cash;
3. Make agreement, recording and settlement of trades simultaneous;
4. Make the trade record and the trade itself the same entity; and
5. Ensure that the trading parties can trust each other.

Distributed Ledgers, using Blockchains as transaction stores, give us an increasingly practical and proven technology on which we can achieve all five of these objectives, and thereby maximise the efficiency of investment. We have gone on to propose that tokenisation, and its natural offshoot fractionalisation, would enhance investible assets and improve their trading in five respects:

1. By making transactions more efficient;
2. By improving liquidity;
3. By enhancing transparency;
4. By broadening asset ownership; and
5. By broadening the investible universe.

As the natural platform for tokenisation and fractionalisation, DLs are supportive to the delivery of all five benefits, and thereby enable us to expand the investible universe, democratise access to investment, and increase efficiency, as well as making scrutiny and audit easier and more effective.

The objectives are apparent, the tools are available and the target is clear: the current model has a bullseye on its chest. The only real question is how best to attain the necessary change: what does a better model, importantly one that we can actually implement and migrate to, look like? The second part of this paper sets out to answer that question.

4. Pledges, IOUs and Smart Tokens

The best way to digitise assets is to stop treating them as indivisible things, and to represent them instead as they really are: as a set of pledged rights to future flows[82]. This is the first key step. Moving intelligence out of business systems and onto the tokens is the second key step. Self-execution of the tokens themselves is the third key step. Fractionalised trading of tokens at the flow level is the fourth step. Valuation and risk management at the flow level is the fifth. With all five steps in place, the digital market can fulfil its potential, and deliver profound benefits.

Getting the Model Right

Why Getting the Model Right is Important

In the first part of this paper, we established that the wrong underlying model of representation (in this case of transactions in conventional assets) leads to a string of unintended consequences, and to layers of costly, complex mitigations to patch their negative effects. This is redolent of a dying scientific paradigm. Ptolemy's geocentric model, for example, which dominated the science of astronomy for two millennia, placed the Earth at the centre of the Universe. As it was confronted with a string of astronomical observations that were inconsistent with the model, increasingly complex and unlikely modifications to the theory (along with unobserved and fictitious celestial entities), were proposed to keep the struggling model afloat. Despite these patches (and accompanying religious persecutions), the weight of evidence behind the superior, heliocentric model of Copernicus finally condemned geocentricity to death.

The previous chapter demonstrated that our model of assets and transactions is long-established, and revered in the same way as Ptolemaic astronomy, but outdated and unfit for purpose in a digital context. It is a ramshackle evolution of the ancient process for exchanging goods for gold. Like geocentricity, keeping our current model of assets and transactions afloat requires increasingly unlikely and costly patches, and a rash of additional entities. As we move to digital assets, the contradictions between the current model and what is actually happening will reach breaking point: we need to get the model right, and scrap the patches.

In this part of the paper, we go from critical analysis to constructive solution, and elaborate a powerful alternative model. It is a model that is workable across all financial products, asset types and transaction types, while avoiding the unintended, costly consequences of our current model. We show that this model is attainable with digital assets, and document its substantial benefits.

Getting Away from the Need for Things to Own

When we transact, we have a natural desire to own something afterwards: there has to be a 'thing' that we have bought, an asset that we can hold on to. We construct trading systems to move these things around, inventory systems to record the things that we own, and custody systems to hold the things that we own securely for us. We see the thing – the asset – as fundamental.

The existence of things is convenient from the perspectives of multiple market participants. Law-makers can legislate about the kinds of things that are permissible, how they are taxed, what their ownership means, and how it is transferred. Lawyers can opine on the rights and obligations of the owners of things, and argue about the kinds of things we are dealing with in any particular dispute. Regulators can define roles and standards for those who handle, hold or shunt the things around. Accountants can work out the value of the things. Auditors can check if the things are where they should be.

The fact that often, in reality, there is nothing to own at all is lost in the familiarity, and apparent normality of our world view. The truth is that, in financial services, we are as far away from an accurate representation of assets and transactions as early physicists were from

[82] This is not a wholly new idea: OTC derivatives provide a relevant precedent. They developed strongly once we accepted that contracts could commit future conditional flows or exchanges.

an accurate view of matter, when they described it as comprising earth, water, fire and air. Owning 'things' is comfortable and familiar, but removed from the reality of what is actually going on. Geocentricity was comfortable and familiar, but wrong.

There are powerful benefits in cost, control, risk management, operational simplicity and market transparency to be had if we make our representation of ownership true to reality. This means being prepared to retire 'things' as the raw material of all investment, and to ditch the allegorical patches and processes that we have built up around them.

Replacing Things with Pledges

When we 'buy a bond', we do not end up with a single, unitary thing that we can hold, as if it were a toy train, or a banana. What we get is a set of contractual pledges[83], like a fistful of IOUs, representing rights to the future flows of the bond. At the simplest level, each pledge commits one issuer to deliver one flow of value to one recipient. The issuer (or seller) gets some cash, which in our tokenised world, will be cash tokens. These, like other forms of cash, are also normally promises of a sort: they are bank liabilities, promising to pay the bearer the due amount, on presentation to a central bank.

It is critical that the smart tokens are issued at the level of the individual pledge (and therefore of the individual flow), rather than at the asset level. If we issue tokens at the asset level, then we concretise our current view of assets and asset types, and the game is lost before kick-off. The issuance of tokens at the pledged flow level, rather than the asset level, is key to the implementation of a common operating model, and therefore the key to very substantial benefits.

The future flows pledged in the IOUs are token flows too: again, in the case of a bond, they will be cash tokens, but in other examples they may be other forms of token[84]. This concept is not entirely new or strange; for example, the Regulated Liability Network standard, proposed by Tony McLaughlin of Citibank[85] , and the basis for SETL / Digital Asset's proposed token issuance network, is based on promises, not assets.

The risk of the bond is not unitary. Each pledge has an individual risk of failure, which is basically a function of the solidity of the entity making the pledge (i.e. the pledgor, or issuer) and the timing of the pledged flow. However solid the pledgor is now, our confidence in their solidity at the time of the committed flow will decrease in proportion to the distance between now and when the flow is due to happen. Our valuation of the flow should be adjusted accordingly: this is not discounting, but risk adjustment. If we need to discount the flows, then DCF[86] should be applied on top of the risk-adjusted value.

The model here is closer to accounting payables and receivables than to conventional investment accounting, except that accounting payables and receivables are valued at par, and are always in cash. In our model, the values are sensitive to risk, and the flows may be in any token. In conventional investment accounting, we value a position in the bond, because the old model is that we own a thing, and the thing is in our inventory. In a model truer to reality, we would value the pledged flows. If we want to add them up and say that this is the value of the bond, then we can do so, but it adds little value; indeed, over time it will be meaningless, as we will see further on.

What we can do usefully is to put a label on a fistful ('cluster') of pledges which share a common pattern or template. This shorthand will make it easier for us to communicate the content of the cluster of pledges, and to trade, organise and manage them. Clearly, while this is asset-like, these clusters are wider in scope than conventional assets, and we can add a label to any cluster that we choose, without restriction. Conversely, the existence of standardised templates and common labels in no way restricts the ability of any holder to trade any pledge or cluster of pledges that they choose.

[83] Pedants may claim that a promise is still a 'thing', because 'promise' is a noun; but even the most pedantic would probably agree that it is not in itself a physical thing, likely to be custodied or held in a vault.

[84] There are echoes here of the Actus FRF standard, developed after the 2007 crash and credit crunch, which aims to reduce all securities and financial assets to standard sets of cash flows and standard contracts, to facilitate their representation and management. See https://www.actusfrf.org/about

[85] See: https://www.citibank.com/tts/insights/articles/article191.html

[86] Discounted Cash Flow, which reduces the value of future flows to reflect the opportunity cost of funding, rather than the risk of default.

Trading and Fractionalisation of Pledges

Because the committed flows are carried on tokens and each pledge is represented separately, they can be traded independently, and fractionalised at will. So there is no need to trade the full cluster of pledges (i.e. the whole bond) at once, and any individual flow (or arbitrary set of flows) can be further traded in fractions. As a result, over time, the original cluster of tokens may become unrecognisable through selective and fractionalised trading, both outbound and inbound.

What matters is the overall set of flows that I am committed to, and that are committed to me, not the original cluster that I happened to acquire at a particular point in time (labelled or not). There is simply no purpose in trying to maintain a single view of the original 'bond' as a coherent thing. We should just accept that it is not a persistent thing at all: it is very likely to have been nibbled to death by partial and fractional trading, outbound and inbound.

It is like Trigger talking about his broom in Only Fools and Horses[87]: "I've maintained this old broom for 20 years. It's had 17 new heads and 14 new handles in its time." Sid replies: "How the hell can it be the same broom then?". The truth is that there is no persistent identity that is Trigger's broom: there is just a collection of handles and a collection of brushes that exist over time. That it is convenient to cluster one of each at any one time, and label it "Trigger's broom", is undeniable, but it does not mean that there is any persistent thing with that name. All that it does is to facilitate vacuous philosophical debates about the nature of identity. The smart token model deals with handles and brushes, and doesn't speculate about Trigger's broom: it is not a persistent asset.

As set out at the start of the introduction to this paper, financial products are here to transfer value over time: their true purpose is to deliver the right flows at the right time for issuers and investors, not to maintain an inventory. The consequence is striking and powerful, that assets are an unhelpful distraction in the real business of finance: we should focus on flows, not assets.

If you hold a token that contains a pledge signed by another party, then they are the issuer and you are the recipient (i.e. the beneficiary of the pledged flow). The identity of the issuer of the pledge is key, as they have made the commitment, and your risk is against them. They prove their identity with a secure signature on the token. You remain the recipient unless and until you sell the token (or a fraction of the token) to someone else. Selling the token doesn't change the issuer of the pledge, just its beneficiary, and therefore the location at which the token is held. The recipient's risk against the issuer is sold with the token, and the pledge that it contains: no matter how many times a pledge is sold or fractionalised, it remains the obligation of the issuer to deliver the flow that it defines. When any pledge is discharged, it is always settled by its original issuer[88].

Each pledge commits one flow from one issuer to one recipient, conditionally or unconditionally. If the pledge is for exchange, then that creates a link between two pledges, but this link is only effective at the point of settlement. The pledges operate independently until then, and can be sold and / or fractionalised separately. However, neither will settle if the other either doesn't exist, or if its issuer doesn't have the tokens available when settlement occurs.

Making Tokens Smart

Self-Execution, Triggering and Compliance

We are used to the idea that relatively smart, but static business systems have the ability to push not-very-smart, but mobile chunks of data and messages around. In a DL context, this means business applications embodied in smart contracts, located at the nodes, moving data (and tokens) between the nodes. The nodes are empowered to do this: they host the business apps, and the tokens go where the business apps tell them to go. In an R3 Corda context, for example, this hegemony is implemented by Cordapps[89] at the nodes, deploying smart contracts and calling the shots.

[87] Only Fools and Horses was a classic BBC situation comedy which ran from 1981 to 2003.

[88] Strictly, unless the issuer has contracted with another party to settle on its behalf.

[89] "Cordapps" is the name given by R3 to Corda Distributed Applications, which run on nodes, control flows between nodes and allow nodes to reach consensus on transactions.

Smart tokens turn this model on its head. In a smart token model, the things that move (namely. the tokens themselves) acquire the intelligence, know what they can do, and are empowered to do it. It is smart contracts, coded onto the tokens, that create and manage flows between the nodes. In other words, the nodes lose most of their intelligence and become more like passive receptacles for the tokens. A pleasing corollary is that smart tokens can all be very much alike, while supporting widely diverse business functions; in parallel, the functions left at the nodes become simpler and less differentiated. It's win-win[90].

This intelligence is what brings tokens, as containers for pledges, to life. The pledges are binding on the issuer, who affirms the liability through a digital signature, tied to their digital identity. In that raw form, they are still merely data, and they still need coded technology and process to shunt them around and to give them effect. What the smart token model does is to shift that capability and process from the nodes to the tokens themselves. Metaphorically, the token knows what it must do (to itself and to other tokens), and actuates and executes itself, rather than relying on a third-party system to breathe life into it. This is why we call them 'smart tokens'. Each smart token fulfils a key rule of digital transaction, because it is a single record, supporting a single set of computations: there are no local versions of it, maintained or processed by the issuer or the recipient in their own systems: it is a single copy shared by both parties.

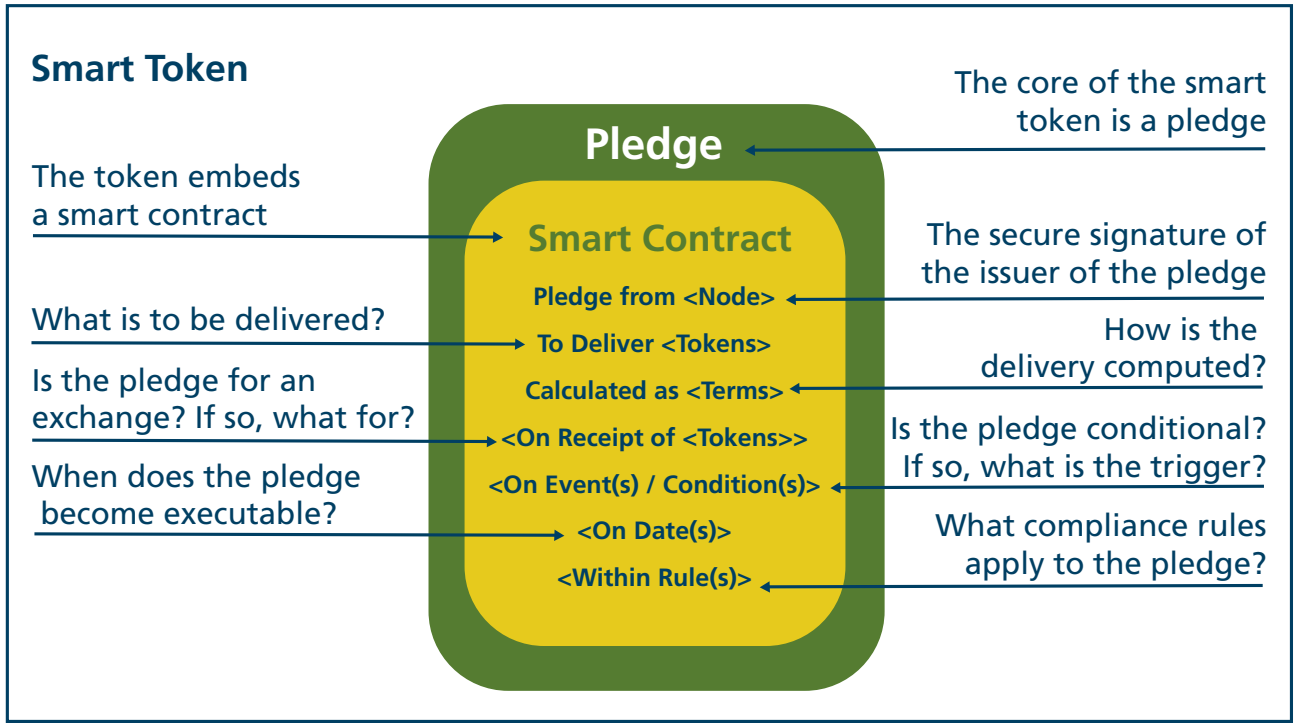
[90] It is very much a win-win, but to achieve it will require the distributed ledger infrastructures to step up and explicitly support the deployment of smart contracts on tokens.

Moving the coded intelligence onto the tokens gives us much greater flexibility in implementing change and launching new products. We just need to define the terms of a new token, and our (operational and technology) work in launching the new business is largely done. Self-execution gives a token the ability to carry out its tasks without intervention from the issuer or from the recipient of the token. It is therefore beneficial in establishing independence in execution and in reducing workload for the participants: it implements what has already been agreed by the parties.

If the smart token is to self-execute, then it needs to know the flow(s) that it is pledged to deliver to the recipients / beneficiaries. It needs to know the nodes that these flows will run between. It needs to know the timing (for example, payment is due on 1st July) and the conditions (for example, payment is due when RPI exceeds 4%) that will trigger it into life. It also needs to know any constraints that could restrict or change the delivery of the pledge (for example, no transfer can be made to a party in a certain jurisdiction). Compliance to legal and regulatory constraints, including any limitation on the type of investor that a pledge can be sold to, is a key capability of a smart token.

Like compliance constraints, the contractual terms of pledges can be coded onto the smart tokens. This does not mean coding of all of the current contractual terms of a lengthy legal document. For smart tokens, the legal context is much simpler: the number of things that can happen to a smart token, and the number of things that they can make happen themselves, are both very limited. Consequently, the potential contractual terms which govern the behaviour and effect of the tokens are limited too.

The standard pattern of a smart token is shown below.



The New Types of Token

Currently, in most implementations of tokenisation (outside cryptocurrencies and NFTs), there are at most two kinds of token: those representing title to assets and those representing title to cash. These tokens purely exhibit title to some off-ledger value-store or thing. The cash tokens can be converted to and from fiat currency, while the asset tokens are similar to shares, and constitute proof of title. They may even be exchangeable for conventional shares, in the same way that the cash tokens are exchangeable for fiat cash. Neither defines its own behaviour (or that of any other token), or has any self-enacting properties. These current versions of tokens are not smart: they are dependent on the intelligence and functionality of business logic built and operated at the nodes, to shunt them around in a productive, compliant and contractually sound way.

We can do some useful things with dumb tokens, and they can support both atomic settlement[91] and a self-maintaining registry. However, their lack of coded intelligence is inherently limiting, and they cannot deliver a total transformation of investment economics in that limited form. In this paper, we propose instead the creation of intelligent, self-executing smart tokens, which do know what they can do, and do have the power to do it.

The consequence of the model proposed is that we need to add two digital token types to the ledger universe, in addition to the 'dumb' title tokens. As a result, there will be four kinds of token in total, populating our ledger: these are split between asset and cash tokens in one dimension, and digital and title tokens in the other. The token types will be:

1. Cash title tokens;
2. Asset title tokens;
3. Digital cash tokens; and
4. Digital asset tokens – 'smart tokens' for short.

In more detail:

1. Cash title tokens are familiar, and represent title to part of an off-ledger fiat cash pool, or to a fragment of a bank's balance sheet; they are essentially dumb, but could carry on-board compliance rules that govern, for example, who they can be transferred to;
2. Asset title tokens are also essentially dumb (with the exception of carrying compliance rules), and represent title to a fraction of an off-ledger thing, like a company, a pool of assets or a Leonardo;
3. Digital cash tokens are fairly smart: the cash is issued only on-ledger (i.e. with no reference to an off-ledger cash pool), and value is pledged directly from an issuer of currency, likely to be a Central or Commercial Bank. They manage their own validity, know who can hold them, and can turn themselves in for periodic reissuance;
4. Smart tokens are very smart, and pledge the issuer to future on-ledger flows of cash or asset tokens of any kind. They are issued and valued only on-ledger (i.e. with no title to an off-ledger thing), know what they can do with themselves, know what they can do with other tokens, and have the capability to do both.

In summary, both smart tokens and digital cash tokens exist exclusively in an on-ledger world, and make no reference to off-ledger entities. Cash and asset title tokens, on the other hand, have value only because they reference, and provide entitlement to, entities with off-ledger value.

Ownership of Tokens

Ownership of tokens is fundamentally a simple construct. If the token is held at your node (or its address is owned by you), then you own it[92]. If the token moves (or its address changes), then the ownership moves. Commonly, a trade will involve a simultaneous exchange of tokens, normally cash tokens one way for asset tokens the other, in an 'atomic' settlement: this is a perfect tokenised equivalent of delivery versus payment (DVP). However, trades could involve transfers of tokens of any form, and are not tied to an exchange of cash against asset tokens.

Like any other IOU, if I hold your IOU, then you owe me money (or some thing or service). When you discharge your debt, I give you the IOU back. Smart tokens are the same: the token is held by the beneficiary / recipient, until the pledge that it contains is delivered on, then it is sent back to the issuer, to do whatever they choose with. The recipient can sell the smart token in whole or in part without restriction (other than from regulation), but the liability remains with the issuer. Whoever ends up holding the IOU when the commitment is discharged, the IOU is sent back to the original issuer, not to the last seller of the pledge.

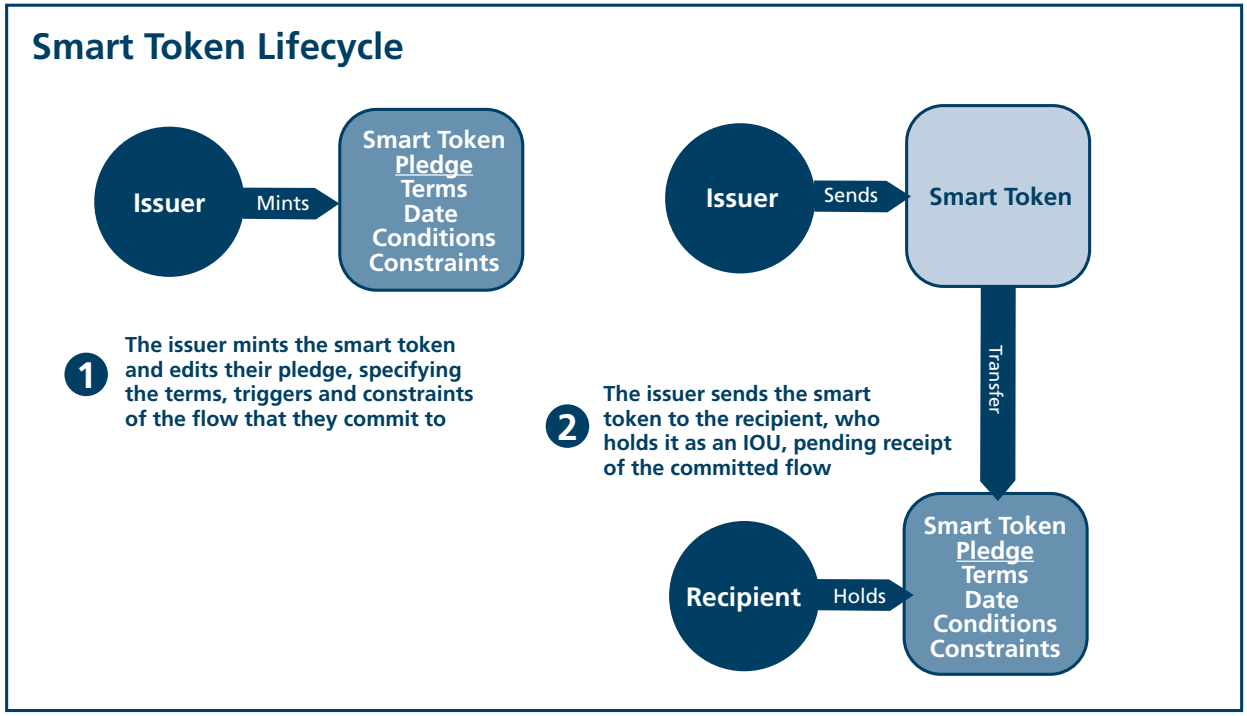
91 - Atomic settlement is the simultaneous movement of tokens between nodes, usually a cash token one way and an asset token the other way, to achieve settlement, in a tokenised equivalent of perfect Delivery vs Payment (DVP). Except that there is no delivery and no payment, just token transfer.

92 - In other DL contexts, this would be an address on a blockchain. If you own the address, you own the token.

This model is inherently superior to the conventional model where the buyer owns an instance of the asset, but both the buyer and seller (and the issuer in income / corporate action events) are still involved in, and initiate settlement. Holding the smart token (i.e. the IOU) at the recipient node means that the recipient owns and controls it, but all the work is done by the smart token itself. The only thing that the issuer has to do is to have the committed tokens available at their node in time for settlement (or to default[93]). Although they hold the smart token / IOU, the recipient can't change the terms of the smart token, as they are locked with the issuer's secure signature.

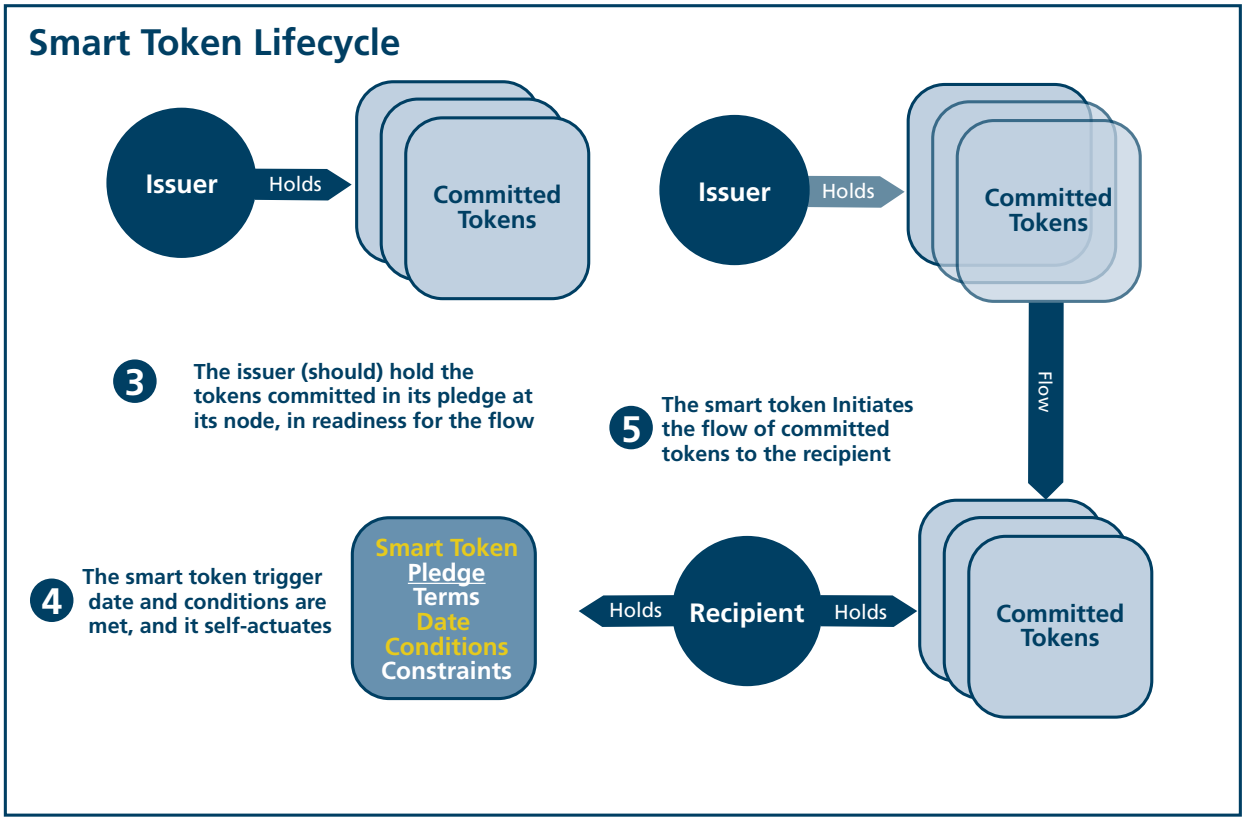
The Smart Token Life-Cycle

Bringing together the above perspectives on smart tokens, their locations and their behaviours, the following pictures summarise their lifecycle.

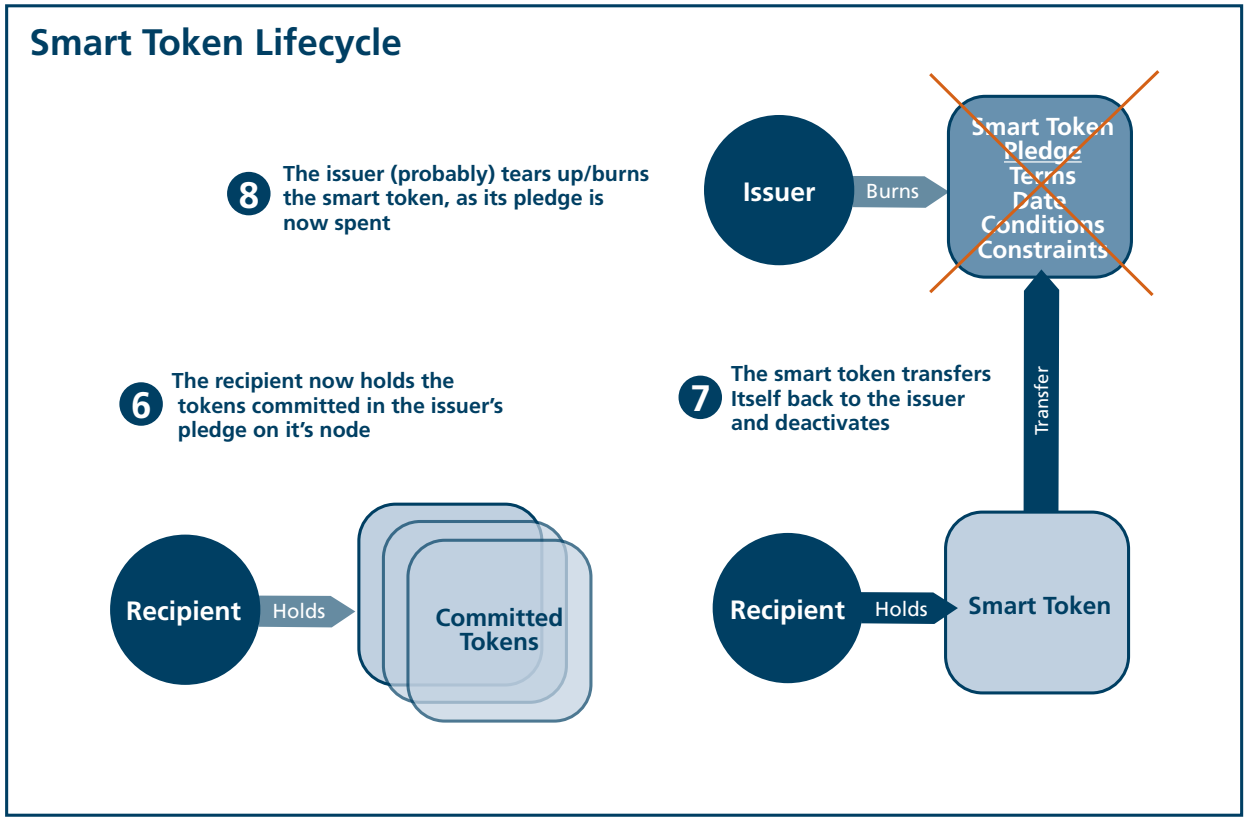


[93] For further discussion of default, see the section below on Smart Token Analytics – Risk and Valuation.

First, the issuer creates the smart token, by defining the pledge that they wish to make, minting / issuing it as a token, and signing it to underwrite their identify as the pledgor (1). Once issued, the issuer sends the smart token to the recipient, who holds it as an IOU (2). The recipient will keep the smart token until the pledge that it contains is delivered to.



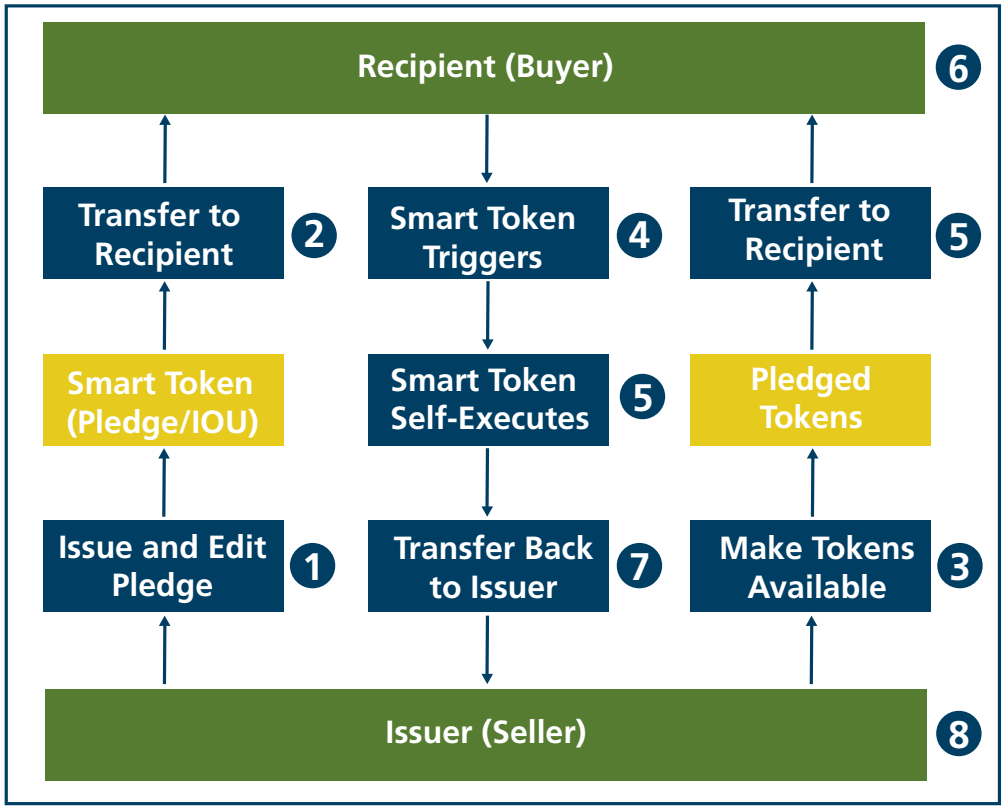
In advance of the expected triggering of the smart token, the issuer is responsible for ensuring that the tokens committed in the pledge are available at its node (3). When the trigger date is reached and / or the trigger conditions are met, then the smart tone self-actuates (4). The activated smart token self-executes, evaluates the terms of the flow, and initiates the flow of tokens from the issuer to the recipient (5). This will fail if the committed tokens are not available at the issuer's node.



So long as the committed tokens were available, then they are now held on the recipient's node (6). Once the flow is complete, then the smart token (i.e. the IOU) sends itself back to the issuer (7). The issuer can do want it likes with the smart token, but is likely to burn it (8). However, if it wishes to make the same pledge to another recipient, then the issuer can reuse the token at its discretion.

Summarising these steps, the lifecycle of every smart token can be represented simply, as follows.

1. The issuer defines the pledged flow and creates / issues the smart token;
2. The issuer transfers the smart token, effectively as an IOU, to the recipient of the pledge;
3. The issuer ensures that it has the pledged tokens available at its node, pre-settlement;
4. The smart token self-actuates when its trigger date and / or conditions are met;
5. The smart token self-executes, evaluates the terms, and initiates the flow from the issuer;
6. The recipient now holds the pledged tokens at its node;
7. The smart token sends itself back to the issuer;
8. The issuer burns the smart token, in effect 'tearing up' the IOU.



In this lifecycle, there are no intermediaries between the issuer and the recipient, and the only entities are the issuer, the recipient, the smart token and the tokens committed by the pledge.

If the smart token is part of a transaction, then there will be two instances of this life-cycle, back-to-back, the trigger conditions will be aligned, and the flow will be bi-directional. More complex transactions, representing the equivalent of conventional asset lifecycles, just deploy multiple lifecycles in parallel. The lifecycles will be identical, while the committed tokens and the trigger conditions may differ as required. There is therefore no difference in the operating model, no matter how apparently complex the 'asset' or the transaction appears to be.

Atomic Theory and Smart Tokens

At a basic level, just as each pledge commits a single flow, so each self-executable smart token commits one issuer to one future flow of tokens to one recipient, conditionally or unconditionally. These are the atoms of our model. Everything else, from clusters through to full asset and liability profiles for major participants, is ultimately built out of these atomic components. Like quantum computing, we use generality at particle-level to create enormous power and flexibility at operational level.

The conventional model of assets does this the other way around, and is driven rigidly top-down. Conventionally, we first define the asset classes and their attributes; then, driven by their diverse terms and conditions, we break each asset type down into operational components and activities, which are different for each instrument class. It is as if, in particle physics, we first defined planes, trains and automobiles, then defined a different atomic theory to explain each of them. This handcuffs us to those asset types, eliminates flexibility and extinguishes generality. If we have any choice, it's no way to go, and we do have choice.

Minimum Platform Requirements

The emphasis of this paper is on the issuance and transaction model, rather than on the specification of infrastructure. We saw in the first part of the paper that Distributed Ledger platforms have real strengths in a tokenisation context, but they are not essential for implementation of a smart token model.

What is essential is that any platform on which the model is implemented should support:

- The coding of triggers, terms and constraints on tokens;
- The facility to self-actuate and self-execute for tokens;
- The facility for nodes to fractionalise tokens, and for tokens to fractionalise themselves in a zero-value split;
- The facility for tokens to move themselves and other tokens between nodes (or to change their addresses if immobilised);
- The facility for nodes to turn themselves in to their issuing node for periodic consolidation and reissuance;
- The establishment of trust between all participants, such that they know that they have all met the same gating criteria, and have no history of default;
- The establishment of trust between trading parties, such that they can have visibility of the tokens committed in a flow or a net settlement; and
- The ability to share a single record between trading parties, and have simultaneous visibility of it.

It is by no means clear that the tokenisation capabilities of the existing prominent DL platforms would be strong enough to support these prerequisites without enhancement. A key consideration is the mechanism for the establishment of trust: while it is not an objective to introduce central intermediaries, and the private / permissioned context provides some level of assurance, there is still a requirement for the validation of transactions. This could be fully decentralised, or could be carried out by a special-purpose service at network level[94]. Either way, it must not be a constraint on scale, or an unreasonable consumer of resource.

[94] I am grateful to a reviewer, Alex Houseman, for pointing out the importance of this choice of trust mechanism.

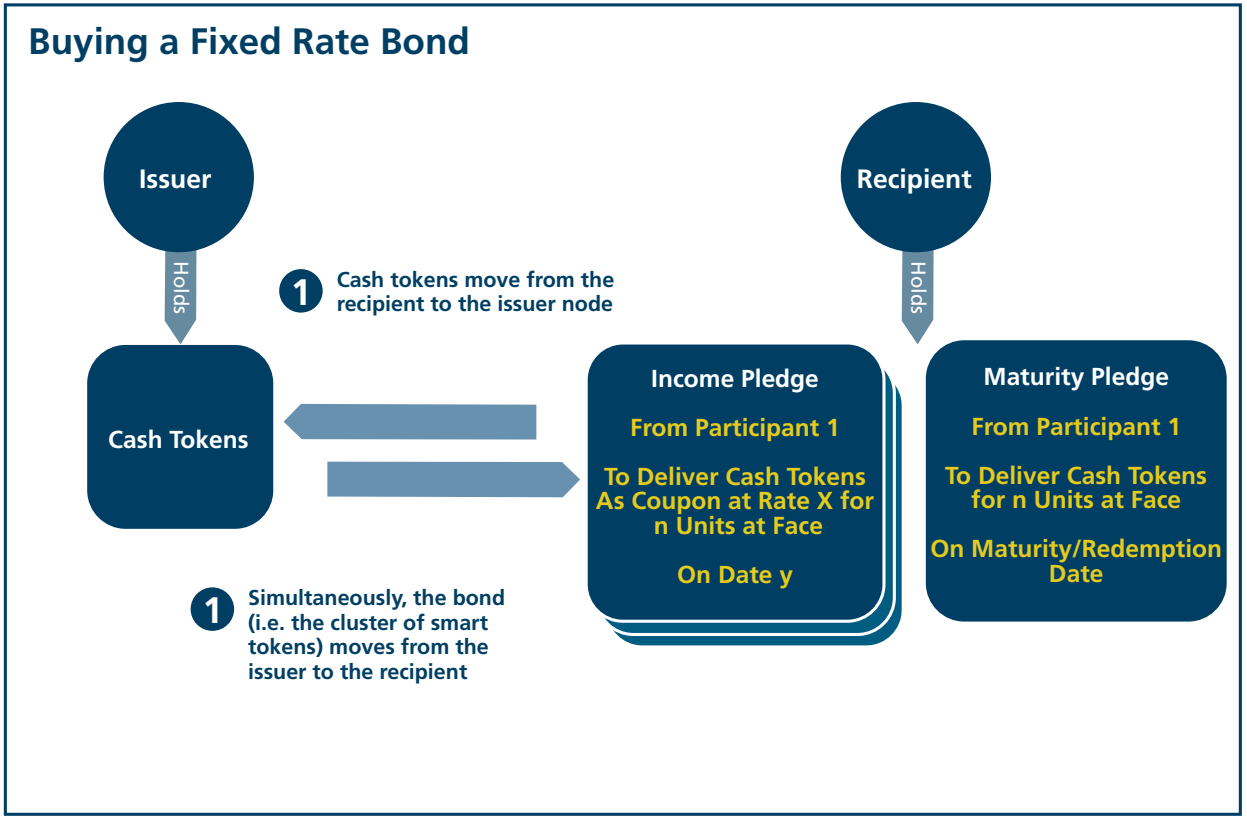
5. Generalisation of the Smart Token Model

The smart token model works (and works really well) across asset classes, across product types and across investment activities. This section canters around the financial universe, showing how smart tokens apply in diverse contexts. Once this is established, we consider what is left for business systems to do, once tokens have inherited most of the intelligence.

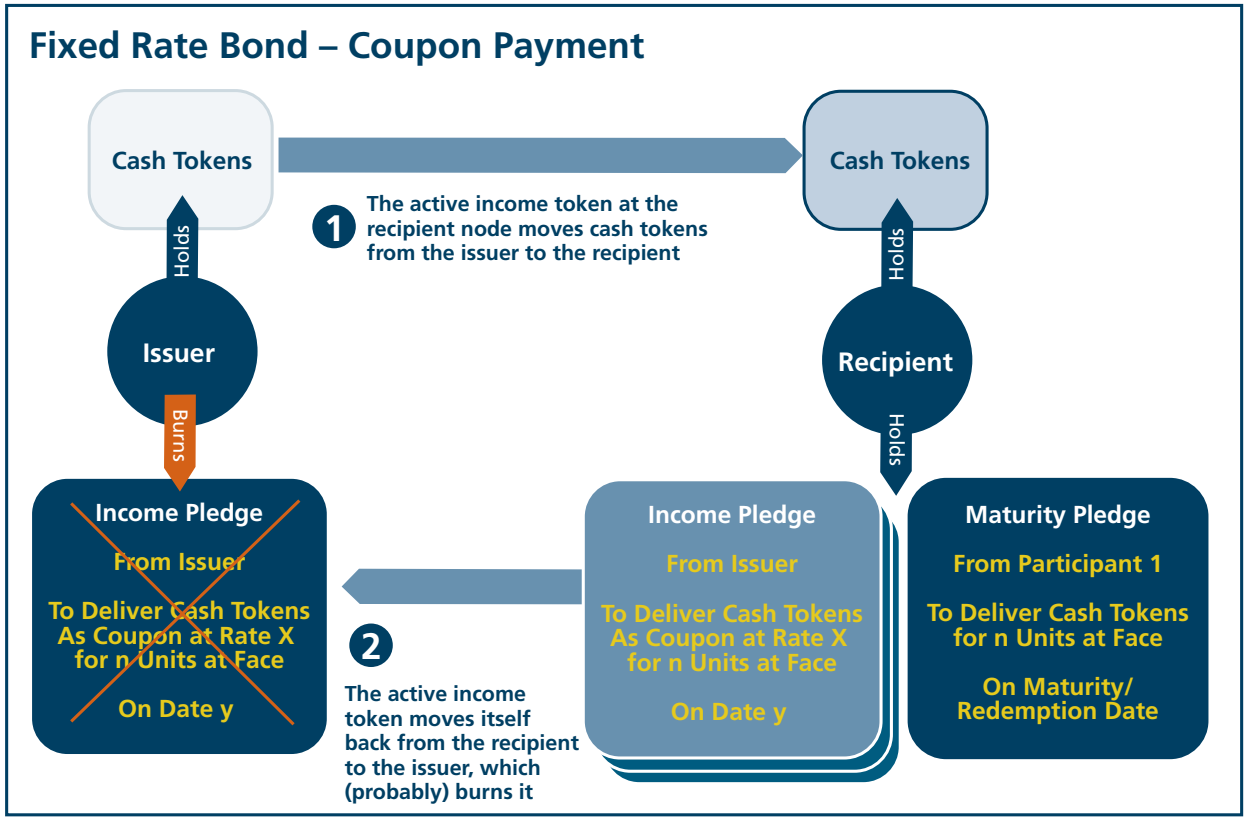
Smart Tokens Applied Across Asset Classes and Product Types

Fixed Rate Bond Example

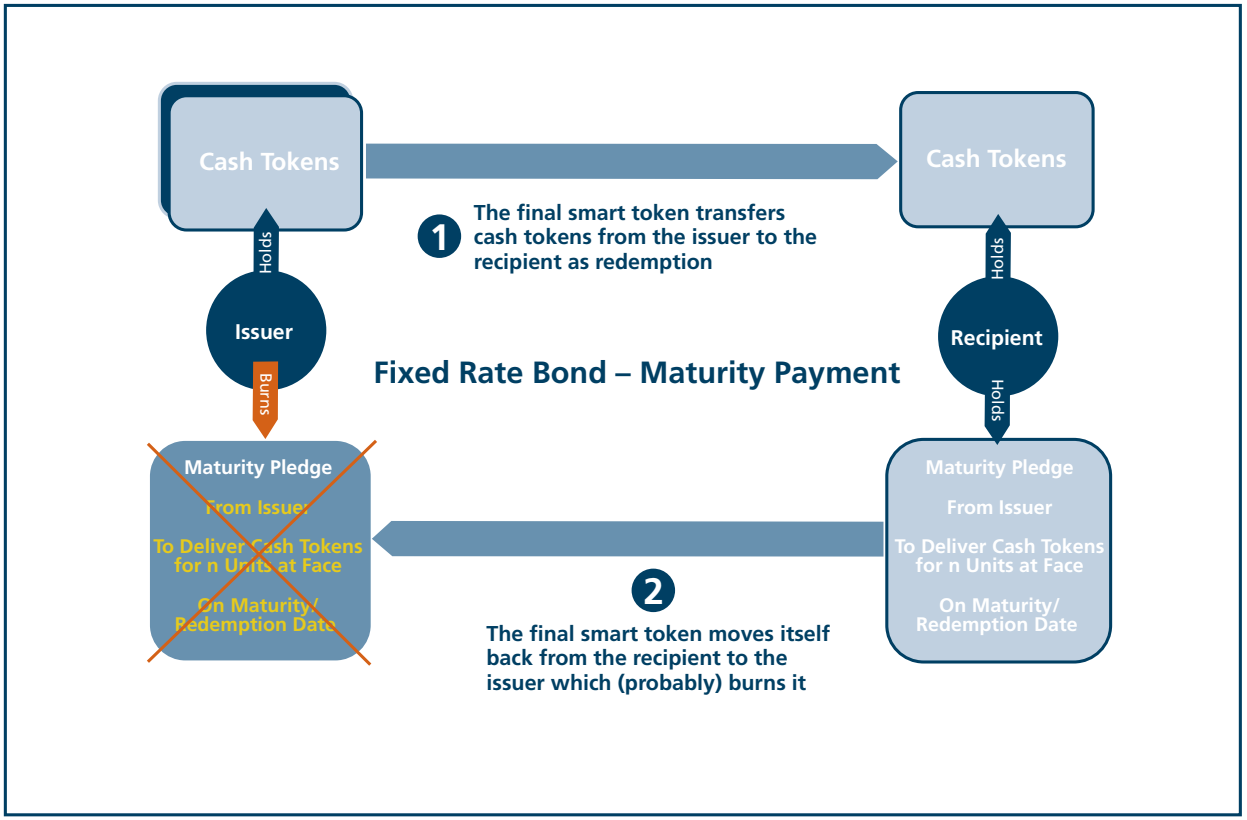
For a fixed rate bond, the initial transaction is the exchange of cash tokens for a cluster of smart tokens, representing pledges to the coupon stream and redemption payment.



When coupon is due for payment, the relevant smart token held by the recipient will self-actuate. It will evaluate the terms of the pledge, and transfer cash tokens from the issuer node to the recipient, then transfer itself back to the issuer. The issuer will probably burn the token, as it is now spent.



Similarly, the redemption payment smart token triggers on the maturity date, evaluates the terms of redemption, and moves cash tokens in settlement. The token then transfers itself back to the issuer



Handling More Complex Scenarios

There are 3 trickier circumstances that the simple fixed term, fixed rate bond example, (conspicuously chosen for its convenience, and set out above) does not exhibit. These tricky attributes are:

1. Pledges whose terms are based on floating values - i.e. that are not fixed at the point that the smart tokens are issued, such as dividend tokens or floating rate bond tokens;
2. Pledges that are perpetual - i.e. that do not have a fixed number of flows, and therefore cannot be represented by a fixed number of tokens, such as perpetual bond tokens; and
3. Tokens whose value relates to the market price of an off-ledger asset, rather being derived 100% from on-ledger flows, such as tokens to a work of art.

These attributes raise challenges for the most simplistic smart token construct; however, all are addressable without damage to the integrity of the model itself.

(1) Variable terms require evaluation at the point of self-execution, or (to be more accurate), at some point before the settlement is self-executed. This evaluation will be defined within the terms of the smart token itself, and may refer to an off-token (but still on-ledger) data source to resolve the variability. In accordance with normal Distributed Ledger idiom, we will call that data source an "Oracle", and assume that it is delivered through a special purpose node on the ledger. So long as the Oracle to be used is agreed between parties to the pledge, and their computations are identical, then there is no need for any separate reconciliation or agreement between the parties. This allows us to deal with, for example, floating rate deposits, variable coupons and the floating legs of swaps. The existence of the Oracles obviates the need for direct access to off-ledger market data by the smart tokens: that is the Oracles' problem.

(2) Perpetual pledges (like the coupon for a perpetual bond, the interest from a perpetual loan, the collateral adjustments from an open repo, or the dividend stream from an equity) cannot be represented by a finite string of individual smart tokens, for the simple reason that the string is unbounded. However, there are standard approaches to valuation of perpetuals in the conventional model, and there are multiple viable approaches to this situation in the smart token model too[95].

All necessarily include:

- A pledge to (at least) the next flow;
- A compound pledge to the subsequent flows in the sequence; and
- A self-executing process whereby the compound pledge generates the next flow pledge, and adjusts its own terms and triggers accordingly.

The pledge to the next flow behaves like any other pledge or IOU, self-evaluates and self-executes, then returns itself to the issuer for disposal. The compound pledge is essentially exchanged for the next specific pledge, and the subsequent version of itself, so it is a risk-free and value-free exchange of like-for-like tokens, managed by the smart tokens themselves.

(3) Where the value of a token is not derived 100% from on-ledger flows, then the implication of holding the token reverts from pure pledge to a title relationship with an off-ledger entity. That off-ledger entity may be inter alia, a work of art, a racehorse, or a company. If it is a company, then the token is an equity token of some form, and the entitlement is to a fraction of the company. Separately, with an equity (whether or not the company is a fund company), there will be a pledge to a stream of dividend (or distribution) flows. This will normally be a perpetual, variable rate pledge, represented in smart tokens.

The point is that under these circumstances, the relationship of the token is to a real 'thing', so things do exist in the model after all. But these things are not assets that we hold on-ledger: they are the off-ledger entities that our tokens provide title to[96]. Their value and risk cannot be computed wholly on-ledger, but there is no reason why an Oracle should not provide their value and risk to our smart tokens, in the same way that it resolves variable terms.

[95] I am grateful to reviewer Dominic Hobson for pointing out that tokenisation does not itself change the underlying (projected) cash flows or their values, but may change the inputs (e.g. by being more liquid).

[96] Most NFTs are native on-ledger, but they can provide an apparent counter example here, as sometimes they relate to off-ledger entities. However, where they do reference off-ledger assets, they are at best digital representations of the 'physical' off-ledger entity that they refer to. An NFT may represent the image, smell or canter of a racehorse, but it will never win the 3.30 at Haydock Park.

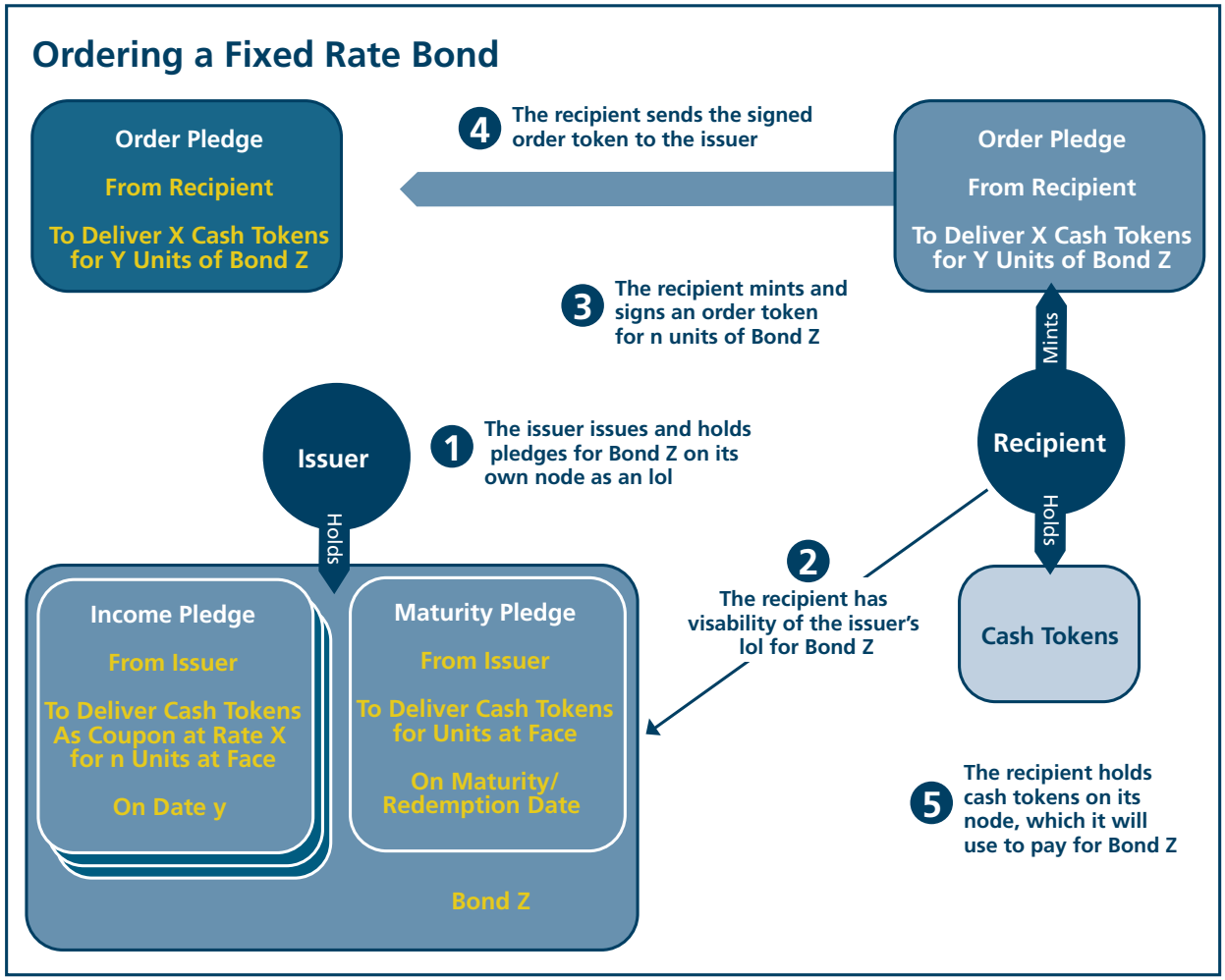
The value of an equity (or of a Picasso or of a piece of jewellery) is not pledged to the recipient of the token by the issuer. It is driven by an assessment of the achievable price for the underlying thing. It is therefore irrational to value an equity at is latest price, without taking account of liquidity, just as it is irrational to value a future pledged on-ledger flow at par, without taking account of the time-based risk adjustment and DCF, driven by our reducing confidence in longer-dated flows, and the opportunity cost of funding.

Orders as Smart Tokens

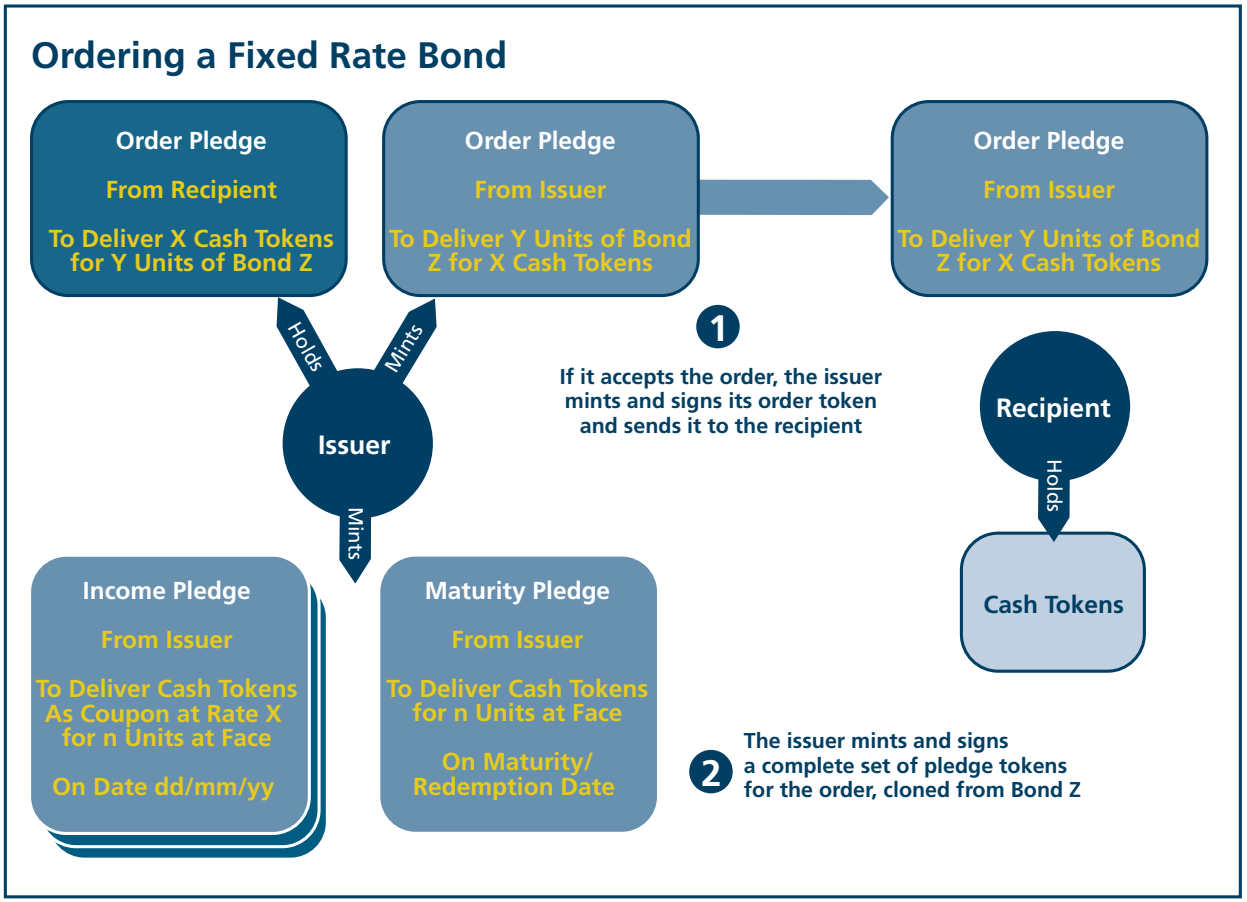
In conventional buy- and sell-side architectures, we have separated out order management from trading and settlement systems, because in our existing thing-centric model, an order is not a thing: it is an agreement about the transfer of ownership of a thing. In a model closer to reality, orders are no different from the movements that they contemplate or commit: they are made of the same atomic particles as everything else in the real financial world. An order is just a matched pair of pledges for future movements. Orders therefore do not need their own business systems in order to function - they can be best represented, by exactly the same smart tokens as represent the flows to be exchanged, and best managed through exactly the same operating model. They are just a flavour of the standard.

Almost always (unless the issuer is generous and the pledge is a gift), the pledge that an issuer would like to make is bi-directional, i.e. a pledge to exchange: in an order, the issuer will want something in return for their pledge. Beyond the order stage, not all pledges will be for exchange: examples of unidirectional pledges include income pledges and redemptions. While those individual pledges may be unidirectional, they are most likely to have resulted from a bi-directional order, for which the issuer will have been compensated, and which will have been reciprocated by the recipient.

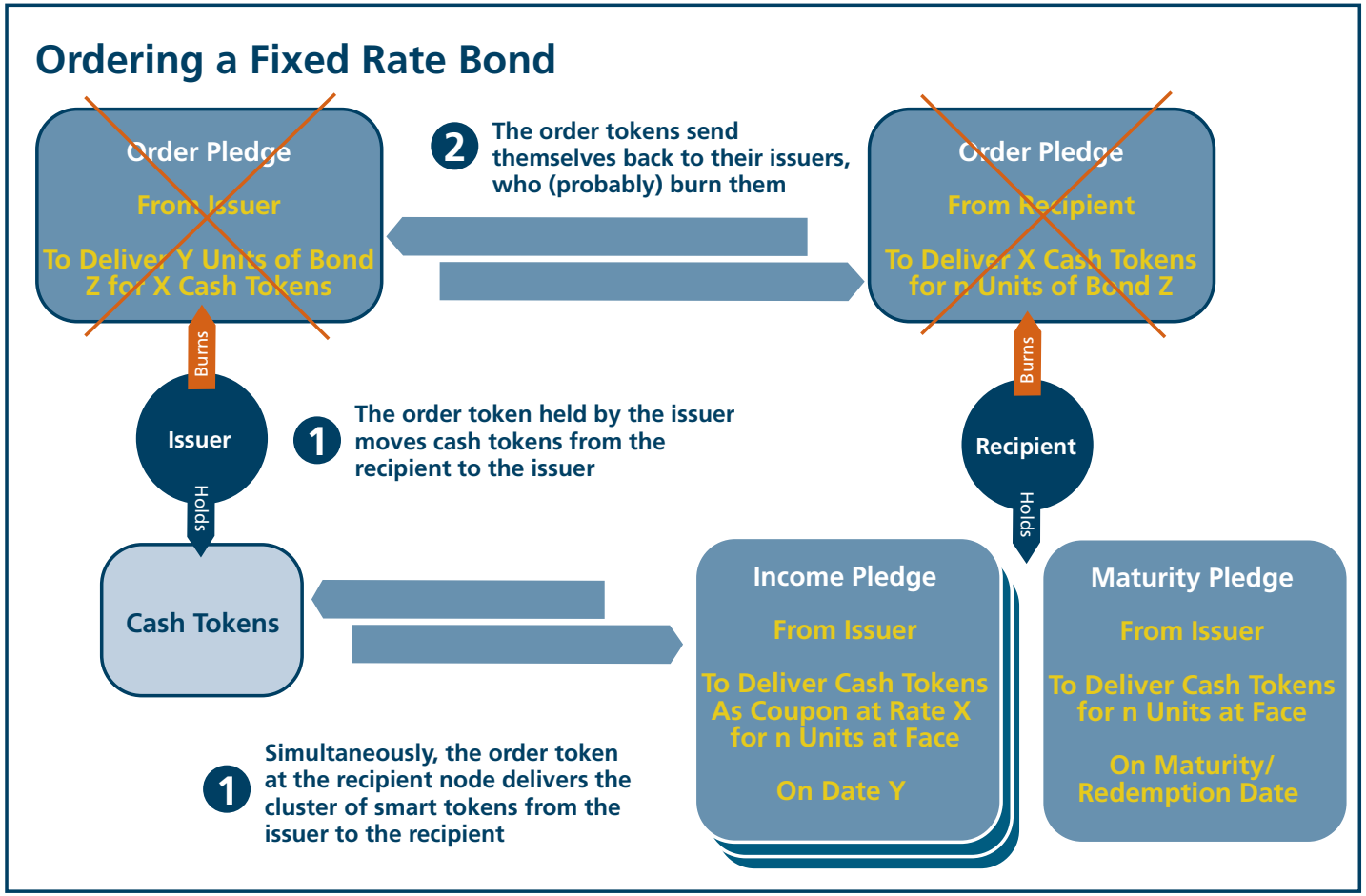
As well as being the receptacle for everything that is yours, your node is also your shop window, displaying your offers and requirements to your chosen circle of nodes. Holding an outbound pledge on the issuer's node, visible to a defined circle of other nodes, advertises the issuer's interest without committing it to a firm flow. So Indications of Interest ('IoIs') and advertisements are just flavours of pledge too: an IoI is just a potential pledge that an issuer would like to make.



In the fixed rate bond example, prior to the exchange of cash tokens for the cluster of pledges representing the bond, the process starts with visibility of the issuer's outbound IoI. The recipient responds by minting and signing a (smart) order token, and sending it to the issuer.



If the issuer accepts the recipient's order, then it mints its own order pledge, committing it to deliver the cluster of tokens which represents the bond. It sends this smart token to the recipient. The issuer mints the specific cluster of smart tokens to be delivered to the recipient; the template for this minting is the IoI which the issuer holds on its node. The terms of the pledges are adjusted to reflect the quantum of the recipient's order.



At the agreed point of settlement, both order tokens self-actuate. The token held by the issuer transfers cash tokens, while the token held by the recipient simultaneously transfers the cluster of smart tokens representing the bond. Once the transfers are complete, then the order tokens send themselves back to their respective issuers to be burnt.

If the issuer signs and sends the pledge to another node (or group of nodes) then it is a firm offer to those nodes, and can be accepted and / or responded to with a reciprocal pledge for exchange. Once both sides hold a signed pledge from the other, then there is a firm commitment, and the respective smart tokens are live and primed: they will self-execute in accordance with their triggers and terms.

If the pledge is for exchange, then as a recipient there is no point in holding a signed pledge from the issuer on your node, unless you have signed the reciprocal pledge and it is held on the issuer's node. Without the reciprocal pledge, the pledge for exchange is guaranteed to create a settlement failure when it attempts to self-execute. There is no 'post-trade limbo', with manual chasing for settlement: the trade just can't happen.

We have seen that an order is generally an agreement to exchange (rather than just a gift), and consequently there are two sides to it. Potential counterparties need to see what their obligations would be if they take up your offer, so the issuer (however the offer is made) needs to make clear to the recipient(s) what they have to pledge in return. The order is a bidirectional pledge in its own right, separate from the pledges that it commits[97]; so this clarity is achieved by the attachment of two forms of template pledges to the order pledge:

1. A template for the reciprocal pledge to the offer, to be minted and signed by the recipient; and
2. A template for the (set of) pledges to be self-executed at the recipient node through the lifecycle of the ordered flows.

In any offered order, the template for the other side's proposed pledge needs to be on window display, alongside your own proposed terms.

[97] For example, buying the equivalent of a bond will involve the bidirectional exchange of a cluster of pledges for a set of cash tokens. The order promises to do that exchange. Once the trade is complete, then the order falls away, leaving the income and maturity pledges to be delivered as they become due.

Negotiation with Smart Tokens

For a pledge for exchange, the issuer can send their signed pledge to their chosen recipient(s); they can reject it if they don't like the deal. However, to accept it they have to mint and issue their own reciprocal pledge, based on the template that they receive, and send it to the original issuer. If they do nothing then the deal is moribund, and the issuer's pledge, while still valid, is stillborn.

Two considerations on negotiation are relevant here:

1. The recipient may want to accept part of the deal (e.g. they want 5, when the issuer offered 10); and
2. The recipient may want to do the deal, but on different terms (e.g. the offered price was 100 but they want to pay 99, or the rate relativity was to RPI but they want CPI)

(1) requires fractionalisation of the issuer's pledge.

(2) requires a change in the terms of the issuer's pledge[98]

The model for negotiation could be based on rejection and counter-pledge from the recipient, leaving the original issuer to accept or reject the countering pledge[99]. This would leave fractionalisation and terms-change up to the issuer, which is appropriate. However, this process would almost certainly lead to lengthy bid and counter-bid exchanges, which ultimately could be wasteful if the process involves manual intervention.

A better model, which would attenuate the bid exchanges, would allow advertisements and IoIs to offer ranges or limits within which the issuer will trade, and automated (and therefore cheap) processes to reach agreement[100].

There is good purpose in having a time limit for response to a pledge for exchange, so that the world does not fill up with stillborn bidirectional pledges with no reciprocal. On reaching its time limit, a smart token can still self-execute, but in this context that means no more than sending itself back to its issuer.

Matching Nodes - A Smart Token Market

The market in a smart token context is very simple. Any participant permitted by regulation can issue smart tokens and send them to a recipient, with or without an order dialogue; this is the primary market. Any participant node can hold tokens (smart or otherwise) issued by someone else as a recipient, fractionalise them and trade them on to other nodes; this is the secondary market.

If the issuing party wishes to remain anonymous (or just to use a third party to find willing takers for their pledge), then they could send their IoI / pledge, along with its reciprocal template, to a 'matching' node, that receives, discloses and matches pledges across a permissioned set of participating nodes. This is the nearest that we get to a central limit order book, familiar in conventional equity markets, in the smart token model of investment. In conventional terms, it is an optimised matching service for bids and offers – in other words, a smart market.

[98] Price can change, but most terms changes can only take place in a primary market negotiation.

[99] The self-execution follows an "auction" process on a Distributed Ledger. This is essentially what the automated market-makers in DeFi (e.g. Uniswap) do: use algorithms to balance supply (effectively, offers or sells) and demand (effectively, bids or buys).

[100] The DeFi model of automated market making may be helpful here.

It is important to see that the smart market does not have to be a separate service, provided by an exchange: it could remain entirely the responsibility of the issuing nodes to seek out matches for their pledges. In some jurisdictions, which prohibit anonymity, they will need to reveal their pledges publicly to make them accessible to searches. A key capability of an outbound smart token would be to search the ledger for its closest reciprocals. This may be a service provided by specialist (and competing) matching nodes, but in principle, matches can be found by nodes, or by smart tokens themselves, unaided.

The matches could be advisory, with acceptance or rejection implemented manually: if accepted, the recipient mints smart tokens from the template, signs them, and transmits them back to the issuer. If rejected, the recipient simply sends the rejected smart token back to its issuer.

As an alternative to manual acceptance / rejection of offers, the optimum matches could be executed by a smart market, or self-executed. If matches are self-executed, then the outbound token could sign and send itself (and the template) to the node with the best fitting reciprocal, issue and sign the relevant reciprocal pledge, and send it back to the issuer. If matches are executed by the matching nodes, then the matching nodes will need to be able to split and consolidate tokens issued by other nodes. This is essential to enable them to match IoIs / pledges between issuers and recipients on a many-to-many basis.

Either could be seen to take automation too far, and neither is by any means essential to the model. However, they are no more scary or self-enacting than the level of automation exhibited by algorithmic trading today.

Collateral Management by Smart Token

Like trading, entitlements, order management, and asset sourcing, collateral management is dramatically simplified through the full implementation of the smart token model. There is no notion of a 'pledged asset' separate from the ubiquitous pledging of flows, representing every other commitment and transaction. The only difference with collateral is that, alongside the delivery of tokens to a recipient node as collateral, there will be 'collateral management pledge', issued by the recipient, and held by the deliverer of the collateral, committing the recipient to the return of the same tokens under defined conditions[101]. If the collateral is subject to adjustment in either direction on a movement in value, then each party will issue a collateral management pledge to the other.

The collateral to be moved will comprise committed tokens of any kind: they do not need to be smart tokens, but they will be tokens of some form. As with every other flow in the smart token model, the movement of these committed tokens is through self-execution of a smart token, in this case of the collateral management pledges. The calculation of the collateral movements is defined in the self-executing terms of the pledges, as are the eligibility criteria and selection process for the collateral. There is no bipartite (or tri-partite) valuation or reconciliation required.

Collateral management is just a flavour of the standard implementation of smart tokens.

Derivative Representation in Smart Tokens

Derivatives are generally seen as challenging, and the OTC variety as inconveniently anarchic, and might be thought of as hard to tokenise. However, once a derivative is seen as it really is, as a set of forward pledges between the contracting parties, then representing it becomes straightforward. In our model of smart tokens and pledges, you could as accurately describe a bond as a simple variant of a derivative, as describe a derivative as a complex variant of a bond. They are both represented in exactly the same way, as a sequence of self-executing pledges, and are processed in exactly the same way, by self-execution of those pledges.

So derivatives are based on repeating pledges to deliver or exchange, and have attached triggers, computations, and evaluations, like any other pledges. They are frequently accompanied by credit / collateral management agreements, which are also represented by pledges. As such, in the smart token world, they are easy to represent, and are represented as they really are.

[101] It has been pointed out that an alternative to this model would be the coding of collateral terms onto the tokens that represent the collateral itself.

It will come as no surprise to the reader that derivatives of any kind are easy to tokenise, because they are just a flavour of the standard implementation of smart tokens. The management and representation of derivatives, which is so challenging, expensive and manual in the conventional investment model, is handled without difficulty or exceptionality in the smart token model.

Futures and Options with Smart Tokens

Futures are straightforward in the smart token model, as they are represented exactly as they are: a pledge for exchange at a future date, with fixed terms.

Options are marginally, but only marginally, more complex to represent, as they include:

1. An initial flow (probably of cash tokens), representing the premium; and
2. A further trigger condition, as well as the forward date for the flows.

The trigger condition could be dependent on the decision of the recipient / holder, or could be simply the fact that the flow is 'in the money' on the forward date, calculated from the comparison of an Oracle-supplied underlying value with a fixed (exercise) value. If the trigger condition is the decision of the recipient, then this will be represented by a token too, and the settlement will be dependent on its transfer to the issuer.

The settlement terms will be defined in the terms of the tokens themselves, and may be:

- A bidirectional flow of asset tokens (title or otherwise) for a flow of cash tokens (the equivalent of physical delivery); or
- A unidirectional, net flow of cash tokens, representing the net value delta (the equivalent of cash settlement).

Of course, these are just the representations of conventional approaches to option settlement. Settlement could also be a flow of any tokens for a flow of any other tokens, giving far greater flexibility in the definition of the option than is currently practical. There is further flexibility in the sizes of options, as there is no need for options to be traded in specific sizes: they can be issued as a cluster with terms of arbitrary size, and fractionalised without restriction. None of this adds complexity for the issuer, as the settlements will be self-actuating and self-executing.

Asset Servicing with Smart Tokens - Income and Corporate Actions

Corporate actions ('CAs') are a persistent and notorious island of bespoke, manual and complex processing. While attempts at standardisation have taken place, and some progress has been made, CAs are still a source of pain and error to many market participants. Tokenisation, and the smart token model, offer the first real solution in a generation.

Income is straightforward in the smart token model, and we have seen it in action in the bond example above. Income is a series of unidirectional, normally unconditional pledges, made by the issuer, held by the recipients, and self-executed when the dates for each income payment trigger. The result is the elimination of any registry maintenance, entitlement calculation, payment and reconciliation activities on the part of the issuers and the recipients (or their respective agents).

Some income pledges may be more challenging than those necessary for the fixed term, fixed rate bond example. It can be an unbounded commitment, rather than a fixed term, and it may be based on floating rather than fixed rates. Models to address these circumstances were set out in the "Handling More Complex Scenarios" section above.

Corporate actions can be more demanding, as they are represented by pledges that are made well after the point of issuance of the reference pledge, and so cannot be pre-agreed definitively on issuance by the parties to a transaction.

Unidirectional corporate action pledges, such as would be required for bonus issues, are pretty straightforward: they can be minted by the issuer at the time of the CA, sent to the recipients, held or rejected by them, and self-executed if they are accepted and held. Discretionary / elective CAs, like rights issues, similarly may be issued at the time that they are proposed, and accepted or rejected by the recipient.

CAs are frequently not discretionary or unidirectional, and require the recipient to give up part of an existing pledge, for example in a conversion, merger or terms change (which swaps a set of tokens for new ones, and adds a one-off flow as a change fee). It is not possible to pre-agree every possible mandatory corporate action on issuance, but it is possible to include in the conditions of issuance, carried on a smart token, that the holder will accept future tokens of a certain kind. Those conditions could be triggered by an Oracle, rather than by the issuer, to maintain objectivity.

In order to self-execute, the bi-directional, non-discretionary CA needs to be represented by a matched pair of smart tokens (i.e. tokens for exchange) with the issuer's pledge held on the recipient's node, and the recipient's pledge on the issuer's node. This means that the recipient must mint a pledge to the issuer.

Essentially, the corporate action in this form is just an order, offered by the issuer, and mandatorily accepted by the recipient. It is dealt with in exactly the same way as an order, through the attachment of a template to the pledge supplied by the issuer. The receipt by the recipient of the issuer's order can trigger the minting, signature and transmission of the templated reciprocal pledge back to the issuer.

Certain types of corporate action, including some of the trickier ones, are very unlikely to be required in the smart token model. Splits and mergers, for example, with their associated price changes and potential misalignments of price and nominal, become irrelevant where trading is at the flow level, rather than at the asset level. Overall, there is a major benefit to market participants in the simplification and self-execution of corporate action (and income) processes.

Unusually in the smart token model, the issuer has to take an active role in the corporate action process: they have visibility of all their outbound pledges, so they have access to what is, in effect, a self-maintaining register: this will enable them to identify the relevant recipients. The self-executing terms of the CA pledges will eliminate entitlement calculation, payment / delivery and reconciliation, but the issuer will still need to send the CA templates and pledges to the recipients. They have visibility of all of those recipients through the ledger, so this is not too demanding, but nonetheless, CAs are not without cost to the issuer. Hopefully, this will disincentivise issuers from over-frequent corporate activity!

Funds share the requirement for mandatory bi-directional corporate actions. Where, for example, an investor is deemed inappropriate, or a fund is to be wound up, the holders of the fund need to surrender their tokens back to the fund, in a process of enforced redemption. This will be represented in a similar fashion to a mandatory, bi-directional corporate action: the fund token will carry conditions for enforced redemption, that will be triggered in accordance with their terms. The fund will provide a template pledge to the recipients, who will mint and sign their smart token, and send it to the issuer. From here on, the process self-executes.

A summary of the above is that asset servicing almost completely disappears as a discrete (and largely manual) activity.

Smart Tokens and Liquidity

While smart tokens do not, of themselves, increase market liquidity, they do facilitate more granular trading. As the holder can sell any future flow that is committed to it, this means that it can also sell the other side of an order, or of a collateral exchange, or of a corporate action, and gain immediate value for it. This is the delivery of real, granular liquidity, where any flow is tradeable, not just whole, grossed up assets. Alongside this improvement in trading flexibility, fractionalisation does increase market liquidity through democratisation, so the overall impact of the model is positive.

Smart Tokens and Liability Management

Every pledge has an issuer and a recipient, and therefore can be seen from both an asset perspective and a liability perspective. Ultimately, when retail payments can be made wholly on-ledger in tokenised form, asset owners will be able to represent both their liabilities (for example, their outbound pension payments) and their assets (i.e. their inbound flows) in the form of smart tokens. Both sides will be visible to them at all times, obviating the requirement for separate asset and liability data management platforms. The liability side can be self-executing, alongside the asset side, which will reduce the role of the scheme secretariat in a pension or insurance scheme.

If the issuer wants to offload all or part of a liability flow, they cannot directly 'sell' the flow to another node, because by definition their pledge is held on the recipient's node and under the control of the recipient.

However, the issuer does have some choices:

- They can offer to buy back the committed flows from the recipient(s) and burn the tokens, in an equivalent of an issuer seeking to reduce its liabilities by buying back its own bonds and cancelling them; or
- They can advertise more widely an interest in the reciprocal, giving value now to another node for committing a flow which mitigates their liability.

In the smart token model, this trading can be at a granular flow level, rather than the asset level, so the match can be much more precise. It doesn't depend on the issuer trading with the actual recipient of the liability that the issuer is trying to reduce, but can involve any willing counterparty. The value that the issuer pays to reduce the liability doesn't even have to be immediate: the issuer could tune its ALM matching by offering outbound value when they are long on inbound flows, and vice versa.

Smart Tokens and Amortising / Collateralised / Callable Assets

Mortgages, and other collateralised, amortising assets are generally seen as among the most challenging securities to represent, process and manage in the conventional asset model. They often have complex terms, embodied in paper contracts, covering collateral and conditions for pay-downs and early repayment, and sometimes for repayment holidays. They present particular challenges in appraising the solidity of the underlying borrowers (or assets), and therefore suffer from challenges in risk management and valuation.

Despite this, asset-backed securities are a prolific asset class.

The smart token model cannot solve issues with underlying risk appraisal, but can provide a very tidy way of representing asset-backed securities, and aligning their representation with other asset classes. As usual, they are represented by a cluster of self-actuating pledges. The initial transaction involves the movement of title to the collateral one way, and movement of a pledge to return it the other way. In a tokenised model, the collateral itself is a token or tokens, which may be title tokens or smart tokens.

Simultaneous with the exchange of collateral and its return pledge, the lender transfers cash tokens to the borrower; the borrower issues a cluster of repayment pledges, in accordance with the template for the transaction supplied by the lender. These are sent (as smart tokens / IOUs) to the lender in the normal way. Early redemption penalties can be represented among this cluster.

The smart token model gives us complete flexibility in paydowns, without operational complexity. Paydowns are an example of liability management, as described above. The borrower cannot sell or modify the repayment pledges, because they are held as IOUs at the lender's node. However, just as with the ALM example above, they can offer to buy them back, or buy pledges to future flows which eliminate or modify their future net payments. The optimised net settlement process (described below) will ensure that the borrower (along with all other settlement participants) only needs to contribute their net commitment of tokens for settlement.

This schema will cover the normal reduction of repayments or term, driven by a paydown, while providing the freedom to define any other modification of the repayment cycle that the borrower wishes to achieve. Repayment holidays and extensions of the loan period can be represented in the same way, and self-executed. Extensions of the repayment period will involve the borrower issuing new pledges beyond the end of the repayment cycle, compensated by a flow of cash tokens at other points in the cycle.

If paydowns are committed to by the lender as part of the 'product', then this means that the lender guarantees that they will be the counterparty to these trades. The lender can provide templates (or signed pledges for the period of the loan) defining the forms of paydown that they will accept. While this commitment is a useful guarantee to the borrower, they do not have to trade with the lender: there is no limitation (other than regulation) on the counterparties that they can trade with to reengineer their repayment cycle.

As always, the terms of the repayment pledges will contain the rules for calculation of the repayments. If these are fixed, then it is simple. If they float, then reference will need to be made to an Oracle, just as for any other floating rate. A rate change is just like a terms-change for a bond, described above as a corporate action, and could be implemented by netting out and re-issuing the pledges for future flows. Callable assets are, in effect, the inverse of a loan with a paydown facility: the call template will be committed to by the recipient, and implemented by new flows which redeem early and net out the future payments.

This all provides the opportunity for the issuance of much more flexible loan products, without paperwork, manual workload and complex operations.

Securitisation by Smart Token

There is no difference between securitisation and any other transaction in the smart token model. If a recipient (in this case a lender) holds pledges from a set of issuers (in this case, borrowers), they can sell any or all of the flows as a cluster to any recipient who is happy (and is allowed) to take them. To make the clusters easier to describe, and more comparable for trading, they may be bundled by characteristics of timing and risk, and packaged with a standardised label for convenience. This does not stop any holder from selling non-standard clusters or individual flows.

Asset Management of Smart Tokens

What will asset managers do when there are no assets, as such, to manage[102]? The answer is that they will do much less, if they continue to try to deliver existing products and services, or do much more if they choose to embrace the new model and deliver more flexible and appropriate products and services to their clients.

With smart tokens, Asset Managers can tailor a portfolio of assets to the liabilities of any individual client more exactly than is possible with conventional securities. They can also broaden liability-driven investment from a specialised and niche area of institutional investment into a service applicable to a much wider population of portfolios and clients.

Managers will use scale to achieve better on-ledger flow trades for their clients than clients could achieve alone. They will manage a large population of flows, and simplify these for their clients, presenting the client with a simple cluster of pledges that reflects their objective profile. Managers will have the choice to commit to these flows, and take risk, or to make them conditional. Where they are committed, then this will open up new revenue opportunities for managers, to compensate them for their pledge risk.

Managers can continue to take active views, both on the valuations of on-ledger flows, and on the values of off-ledger assets. With respect to the former, they can use their own insights to construct bespoke rate projections, default frequencies, time decay and trigger condition probabilities. With respect to the latter, managers may use their own factor insights and fundamental views to speculate on price movements. The off-ledger assets will be tokenised (through title tokens), but their values will continue to be determined by off-ledger factors. In either case, managers will identify tokens and flows that are over-valued and sell them, and conversely identify tokens and flows that are undervalued and buy them for their clients.

Tokenisation and fractionalisation make it much more practical for Asset Managers to run portfolios, built from individualised holdings, for smaller clients. This will open up choice for clients who, to date, have been restricted to investment through inflexible, pooled vehicles, and will open up a new market for Asset Managers.

Alongside this trend to individualised accounts, Managers can deliver a new range of pooled products, but defined by flow outcomes, rather than by asset class or benchmark relativity. These 'token funds' will be represented to the client by smart tokens representing a cluster of flows, and not by title tokens to fund assets (which are essentially the token equivalents of shares). The Manager will therefore be committed to those flows (conditionally or unconditionally), so the balance of risk between the Manager and the clients can be very different from conventional funds. As the smart tokens are no different in form from any other, they can be highly liquid for investors, who can trade them peer-to-peer and fractionalise them as they choose.

Settlement with Smart Tokens

Every trade is settled in tokens, even if those tokens may represent title to cash and / or assets, rather than smart tokens. For trading and settlement purposes, cash tokens, including both digital cash tokens and cash title tokens, are fungible within any one currency, and asset title tokens are fungible within any one reference asset: both unless they have specific compliance conditions attached, restricting fungibility. Smart tokens are fungible if the flows that they commit are fungible, and so long as they have the same trigger conditions and compliance conditions.

[102] With the obvious exception of off-ledger, non-digital assets, represented by title tokens.

Two forms of smart token settlement are possible, corresponding to gross and net settlements in the conventional model. For gross settlement, when the smart tokens trigger, they will claim and transfer the relevant tokens directly from the issuer's node by self-execution – they already have the issuer's agreement to do that. Orders will often be gross-settled, and gross settlement implies pre-funding.

Net settlements are needed to allow the satisfaction of outbound token commitments with inbound deliveries. This enables optimisation of the settlement process, removing the requirement for pre-funding and reducing the demand for settlement liquidity to a provable minimum. It is also essential to enable contra-flows to eliminate or modify future net flows, as they do, for example, in asset / liability management, paydowns and calls. As with any netting process, there will be recognised settlement windows in which netting between flows is possible.

It is a common misconception that the atomic settlement facilitated by tokenisation means that all settlements have to be gross: they do not. Algorithms developed for FundAdminChain[103] demonstrate definitively that, with the right methodology, efficient netting can be achieved alongside atomic settlement, and optimises the funding requirements from all participants in the settlement.

While atomic net settlement (i.e. individual settlements exchanging assets and / or cash tokens within a net settlement sequence) is possible and practical, it is not the most efficient approach to netting. The most efficient settlement can be implemented through a special-purpose settlement node. The smart tokens triggered in the settlement window will move themselves to the settlement node[104], and evaluate their terms. At the settlement node, all fungible flows within the settlement window will be netted for each node, resulting in a single net inbound or outbound flow for each fungible token for each node. These are issued by the settlement node as smart tokens, and self-execute. The triggered smart tokens can then transfer themselves back to their issuers following settlement completion.

The settlement node is, in effect, a clearing node, but the netting is at flow level, not asset level: it also includes all flows (for example, it includes income flows), not just trades. Either the settlement node itself, or specialist liquidity provider nodes, could add liquidity in cash and asset tokens to protect the settlement process (gross or net) from failure on non-delivery. Collectively, settlement optimisation and liquidity provision in the smart token model are equivalent to a clearer and central counterparty in the conventional model. The difference is that liquidity provision can apply universally across all flows, while central counterparties are asset class-specific and tied to a particular operating model.

It follows from these approaches to gross and net settlement that no action or intervention in settlement will be required on the part of any issuer. Their only obligation is to ensure that the relevant tokens are available for each gross settlement, and (net) for each settlement window. The recipients, similarly, have no active role in settlement, as the mechanics of claim, netting and transfer are managed entirely by the settlement node, and by the smart tokens themselves

[103] These algorithms deploy fragmented settlements, including peer-to-peer and cashless transfers. Therefore, while they are entirely practical, current regulation would prohibit their use for principal-traded funds.

[104] Note that, with bi-directional pledges for exchange, a possible triggering condition is that the reciprocal pledge (or pledges if traded in fractions) must transfer simultaneously. Otherwise, neither of the pledges will transfer, so the trade will not settle. Most bi-directional pledges will be orders which will settle gross, and will not be traded, so this would be simple in the majority of cases. Exceptions include physically-settled swaps and options, where forward pledges are necessarily bi-directional.

Smart Token Analytics – Risk and Valuation

Smart Tokens and Risk

The primary obligation of the issuer of a smart token is to have the tokens referenced in the terms of the issue available for delivery to the recipient, at the point that the token self-executes. Failure to do so constitutes a default, and the self-executed settlement will fail. Once the legal implications of pledge are clarified, then it will be clearer what rights the disappointed recipient will have in the case of default on a pledge.

This possibility of default is the primary risk to recipients of smart tokens, and is the driver of risk-adjusted valuations of forward flows, as discussed earlier. The assessment of this risk may be carried out by the owner of the recipient node, or by reference to an Oracle, for example to request a Moody's EDF[105] value. This is the smart token model equivalent of counterparty / entity risk in conventional investment.

The primary risk to an issuer of pledges is that smart tokens may be minted by a third party that commits the issuer to a flow of tokens that they have not pledged themselves. A related risk is the modification of the terms of an issued token by a recipient, to commit the issuer to a more demanding flow. The recipient has a reciprocal risk, that a smart token that they hold may be corruptly changed to reduce the committed flow.

Robust issuer identity needs to be delivered by a strong technical solution for secure signatures, in order to protect against this counterfeit / corrupted token risk. It must not be possible within the technology to issue smart tokens that commit anyone to a future flow other than the issuer itself. It must also be the case that only the issuer can edit the terms of a smart token, and can only do that only when the token is at the issuer's node. Digital identities will be the source for secure signatures (to prove identity, provenance and authenticity) and will provide important assurance. Finally, notarisation will trace back the lineage of any token used in a transaction to its source issuance, to prove its validity.

Despite these protections, every issuer will still need visibility of all smart tokens carrying pledges that purport to commit them to a flow, so that they can monitor for, and identify counterfeits. Counterfeit risk impacts recipients too, as an unidentified counterfeit token will carry a very high risk of default. Recipients need visibility of the committed tokens on the issuer's node, so that they can gain trust and assurance of delivery in advance of settlement. For gross settlement, the recipient just needs visibility of the committed tokens. For net settlement, the recipient needs visibility of both the inbound / outbound flow projection for the node (up to the relevant settlement window), and the net tokens committed to that settlement window at the issuer node.

A secondary risk to the recipient of a pledge is that the rate referenced in the pledge terms reduces, the relevant risk-free rate increases, or their issuers' probability of default increases, meaning that they have paid too much for their forward flows. This is an equivalent of the familiar interest rate and spread risk in conventional fixed income investment. From the issuer's point of view, the risk is the converse: if the pledged rate increases, the risk-free rate reduces or their probability of default falls, then they will have been inadequately compensated for their pledge.

A smart token unsigned, and / or held on the issuer's node, is inactive and inert: it will never self-execute, whatever its terms or triggers say. However, a smart token securely signed by its issuer, and held at another owner's node, is active and primed: it will trigger when the conditions for its self-execution are met. It will then implement the terms of its pledge, subject to any coded conditions, and send itself back to its issuer. Once done, it is done, and the issuer can hold it, reissue it or burn it at their discretion. Like any IOU, once discharged, it no longer belongs to the beneficiary.

This sounds scary - the investment world will be full of live mines, primed to detonate by themselves, like a field full of IEDs[106]. Their fuses are not even lit by the parties from whom value is being taken, and they are physically located with the beneficiary, not with the issuer! Of course, this is not as scary as it may first appear. By signing the smart token and sending it to its recipient in the first place, the issuer has already agreed to fulfil its commitments when they trigger. Those commitments, along with the trigger dates and conditions, are visible to it at all times.

[105] Empirical Default Frequency. See https://www.moodysanalytics.com/-/media/products/EDF-Expected-Default-Frequency-Overview.pdf

[106] Improvised Explosive Devices – i.e. home-made mines.

As it happens, we already have well-established models in financial services where a flow is initiated without the contemporaneous agreement of the payor: direct debits work in exactly this way, commit payors to (often unspecified) payments, and are a wholly accepted model. We do not see them as a minefield, precisely because the payor has agreed to the commitment.

The aggregation of the risk of flows, inbound and outbound, is a fundamental requirement for any participant. As the lowest level of risk is at the flow level, any participant can aggregate risk up through whatever aggregation structure suits their analysis best, without constraint. Within this, there will be little point in aggregating up through assets and asset classes in a conventional risk hierarchy, as assets are not persistent: the clusters that initially represent them will almost certainly have been nibbled away over time, so there will be no coherent assets to attach aggregated risk measures to. Projected time periods for flows, issuer quality bands, and ranges of unmatched liabilities are likely to be more productive as risk aggregation keys.

Valuation of Smart Tokens

The value of a flow defined in a smart token is driven by a series of factors:

1. The evaluation of the terms of the pledge, including any Oracle-sourced rate;
2. The solidity of the issuer of the pledge;
3. The elapsed time between now and the expected self-execution of the pledge;
4. The probability that the trigger conditions of the pledge will be realised; and
5. The probability of the terms of the pledge being changed.

For the first factor, if the terms are fixed, this is straightforward. However, if the terms are floating (including, for example, the value of an option flow on exercise) then this will require a user-supplied value, or more likely, reference to an Oracle for a projected value.

The second and third factors, together, constitute the probability of default on the pledge from counterparty risk over time. The solidity of the issuer may be provided by an Oracle, if the issuer is a recognised institution, or by the holder itself, if it is not. Otherwise, the overall probability of default could be provided (again by an Oracle, for institutions) as an Expected Default Frequency (EDF) measure. To be most useable in a smart token model, EDF measures should be expressed from the Oracle as time-sensitive, i.e. as a curve, rather than as a single value. If they are not, then participants will need to supply their own view of the decay of confidence over time, to factor the single EDF value.

For the fourth factor, if the only trigger is a date, then it is 100% certain to be reached. However, if the condition is more complex, then there may be a possibility that the pledge will not be triggered. For example, in a mortgage liability (or other secured loan), normally the transfer of collateral title back to the borrower will be triggered by the redemption of the mortgage. This redemption is less likely to happen if the value of the mortgage collateral is exceeded by the discounted value of the remaining repayment flows at any time. In other words, if there is negative equity, then the borrowers may leave the keys in the door and walk away, even if they are otherwise fine and upstanding.

The fifth factor practically only applies to pledges relating to loans, where the lender has the right to change the terms periodically. An example again is a mortgage, where new products are offered periodically to an existing borrower, as an alternative to a standard rate. This would be implemented by a new pledge cluster, either to eliminate, or to modify the current repayment cycle, rather than strictly by modification of the terms of the existing pledge. However, there is a probability of change which may be knowable and, if it is, then it should be accommodated in the valuation of the flows.

From the above, we can see that securities with apparently bespoke valuation methods, like options, are not actually special at all. All real flow valuations include considerations of time and probability.

Valuation of Title Tokens

Title tokens are, by definition, referenced to an off-ledger entity, and it is the valuation of this entity that gives value to the token. Their values may be defined by trade prices in an off-ledger market (like equities), by the opinion of an expert (like house prices or works of art) by a social media auction (like items on eBay) or otherwise. In a strict sense, their values are 'arbitrary' – they will be provided by an Oracle, and they are what they are.

However, to be consistent with our valuation of forward flows defined in smart tokens, we should be explicit about, and consistent about, liquidity for title tokens. Title tokens do not define committed flows, but their valuation does imply the existence of a potential transaction with a forward flow. If our assumption is that the forward flow is immediately realisable (or at least realisable by a specific point in time), then we should take account of liquidity, and adjust the values of large holdings downwards accordingly.

Assurance and Smart Tokens

If tokens are held at a node, then they demonstrably exist and are the property of the owner of that node. There is the possibility that private key management could be implemented at the participant nodes to control access to the tokens; otherwise there is no absolute need for a conventional custody service. However, regulators and investors have recognised private key management as a desirable service, and it is increasingly recognised as the nearest equivalent of safe custody in a blockchain environment[107].

As described in this section above, the primary risk to the recipient of a pledge is the default of the issuer. Where there is a commitment to a retail client, for example from an investment manager to deliver specific flows from a pooled product, it will be essential that the underlying flows within the product should support the committed outbound flows. If they do not, then there is a risk of default by the manager; this situation has parallels with the failure of Equitable Life[108], when it was unable to meet its guaranteed annuity obligations. Independent assurance will be required[109]. Similarly, assurance will be required that the valuations of the forward flows themselves are reasonable and realistic.

Control of issued pledges, and therefore of smart tokens, will be a major consideration for issuers. As set out above, issuers will be concerned to ensure that all and only the smart tokens they have issued are in circulation. They have visibility of all tokens issued in their name, so they will be able to ensure that their original issuance is maintained with integrity, irrespective of the number of subsequent trades or fractionalisations of those tokens. There should be no need for third party assurance, or a CSD, in this respect.

It is a major benefit of the smart token model that the number of different entity types, and the number of possible operations on those entities, are very limited. Consequently, the number of points at which scrutiny could be of value is limited too. In the smart token model, while there is still a need for protection and independent assurance, the multiple roles of custodian, fund depository and auditor can be merged into one single assurance function[110].

[107] The loss of private keys is a serious issue for crypto especially. Many 'digital asset custodians' have launched (one list has 84 of them), some of which custody security tokens as well as crypto-currencies. Linking ownership to digital identities would mitigate the risk of loss.

[108] The Equitable Life Assurance Society collapsed in 2000 as a result of its obligations to pay guaranteed annuity products, when the underlying performance of its investments did not adequately support these pledges. https://www.gov.uk/government/publications/report-of-the-equitable-life-inquiry

[109] Assurance is a good idea, but that doesn't mean that it's always effective. Assurance from EY did not save Equitable Life from failure or ignominy.

[110] Naturally, our ability to implement this rationalisation is dependent on regulation.

What Does a Business System Do, Once the Tokens are Smart?

There is strong emphasis in the smart token model on the transfer of intelligence and capability from business systems to tokens. This leaves the nodes, including investor / asset owner and issuer nodes (but excluding special-purpose nodes, like Oracles, matching and settlement nodes):

- With much less to do; and
- With much the same things to do.

Essentially, once we have smart tokens, there is no functional distinction between an investor / asset owner node and a capital issuer / fund node: they are both potential issuers and potential recipients.

Editing and Issuance

Smart tokens do not define, create or destroy themselves, so the things that still need to be done at the nodes focus, critically, on the abilities to edit, mint, issue, hold and burn smart tokens, including functions to:

- Create and edit pledges and their associated triggers, conditions and compliance rules;
- Mint, sign and issue smart tokens embodying those pledges, conditions and rules;
- Create and edit templates for smart tokens, so that they can mint and issue similar tokens repeatedly, or advertise an interest in transaction through an IoI;
- Burn smart tokens that they have issued, and that have been returned to them, either because they have been rejected, or because they have been discharged;
- Burn (one or more) smart tokens that they hold that were issued by other nodes, and issue (one or more) new ones in a zero-risk / zero-value exchange to facilitate fractionalisation;
- Send newly issued tokens / templates to the nodes that they choose, including to any matching nodes;
- Determine acceptance or rejection of discretionary tokens received from other nodes;
- Send back / reject unwanted pledges / tokens; and
- Hold pledges / tokens that they accept (or which are mandatory).

Seeing the Full Picture

Issuers and asset owners need to understand the full set of flows that they are committed to, inbound and outbound: these are their assets and liabilities, with a dimension of time; this is their investment balance sheet.

The inbound flows are represented in smart tokens held on their own nodes, and therefore visible, while the outbound flow tokens sit on the recipient nodes, but will also be visible to their issuer. All nodes need the capability to request evaluations from both sets of smart tokens. This may be on an absolute, and/or risk-adjusted, and/or discounted basis. For flows with floating terms, the fixing rates need to be specified, either as 'what ifs' or as Oracle-sourced values. In any case, the evaluation request needs to be defined and parameterised by the requesting node: it has to have the capability to do that. Clearly, the node owners will develop templates for frequent analyses.

Netting inbound and outbound flows, to understand the participant's forward cash and asset ladder, to identify risk, or to identify asset / liability mismatches, will be central to each participating node. This could be a capability provided at the node itself, or it could be a third-party function, fed from the self-evaluation of the node's committed flows. If matching / smart market nodes are permitted, then this could be a value-add service that they provide to their client nodes.

If their inbound and outbound flows are spread across multiple ledgers, then participants will need to be able to consolidate across ledgers in order to see the full picture of flows, value and risk. This requires inter-operability standards (including consideration of cross-border trades and investment) which are beyond the scope of this paper. However, it is clear that, if the digital issuance model is common across ledgers, then inter-operation will be greatly simplified: in this context, the smart token model would be very helpful indeed.

Finding Liquidity

Participants will need a facility to search the network for liquidity. In the smart token context that means:

- Defining a template for what the participant wishes to trade - this template is really just an outbound IoI; and
- Seeking IoIs at other nodes which match, or are close to, the template.

The search facility may be a capability of the participant node itself, or may be a service offered by a matching node / smart market.

Permissioning

The nodes will need to maintain a permissioning schema. Node owners will want to advertise their interest in creating a transaction, to disclose the availability of forward flows to interested parties, and to make public their appetite for forward flows of a particular profile. They are likely to be uncomfortable doing that publicly[111].

The flows that nodes wish to advertise may be in the form of third-party pledges that they hold, or they may be IoIs, expressing pledges that they are willing to make on their own account. Either way, if they are to disclose their identity, they will want to restrict visibility to a trusted circle of potential counterparties. Permissioning on the platform needs to support the maintenance of multiple circles of interest.

In order to ensure that the right tokens are available for delivery, and to monitor for counterfeit smart tokens, issuers need visibility of all outbound pledges held in their name. The permissioning schema needs to enable that visibility for all issuers of pledges. There is no such concern for recipients, as they hold inbound pledges on their own nodes, but they will want to see that issuers have the tokens pledged to them in advance of settlement, and that the same tokens are not committed to multiple transactions, i.e. that the issuer is not seeking to 'double-spend'.

[111] The integrity of tokenisation also depends on all nodes being visible to all other relevant nodes, which again argues for a permissioned network.

6. Business Case – Challenges and Outcomes

To make optimised digital issuance and digital transaction happen, their benefits have to be recognised and valued, and objections have to be understood and overcome. This section looks at both, as a starting point for the construction of a business case for the smart token model.

Challenges to the Smart Token Model

Generic Negatives

A change as radical as that described in this paper will face a range of powerful (and often reasonable) challenges. The proposed model moves us in the direction of a decentralised future, and the centralised vs decentralised debate is currently raging: the smart token proposal cannot escape its crossfire. The scale of change proposed is also likely to attract negative attitudes, which are defeatist, rather than realistic. Some obvious high-level challenges (and attitudes) include:

- Fundamental change takes a long time to deliver and can be painful. (i.e. We'll all be dead by the time this happens).
- There is a huge amount invested in the current infrastructure, and overhauling it will be a massive challenge logistically and financially. (i.e. It's too hard and will never happen).
- Entities under threat of disintermediation will be strongly opposed to it, and they include major, influential institutions. (i.e. We won't beat the big boys, so it will never happen).
- There is a huge weight of regulation and law, which enshrines the current model of transactions, assets and entities. (i.e. The new model doesn't fit the rulebook, so it will never happen).
- Distributed Ledger Technology is still maturing and unproven at very high volumes[112]. (i.e. It'll never work).

It is inevitable that these challenges (and many others) will be raised, and we should expect them. Doubt will be cast on the feasibility, practicality and realism of a movement for change. However, the socio-economic imperative of efficient investment, and the compelling superiority of the digital flow model, will make conservatism and defeatism hard to sustain: better ideas win over time, and there is a clearly-defined model that is better.

The above are generic objections that could be raised to oppose any radical proposal for change. What follows is a set of more detailed and specific objections (and responses) which apply to the smart tokens model itself.

Transactional Chaos

It is a consequence of the model that there is the freedom to transact at the atomic level. This provides the freedom to achieve whatever profile of flows any participant wants, without limitation or approximation from fixed asset types. It could be alleged that there will be a chaos of very small transactions that will be impossible to track and will overwhelm both participants and regulators.

There is a theoretical possibility that trades could be dominated by small, atomic movements, but this is highly unlikely, and would be inefficient for the participants: they could spend an excessive amount of time defining and seeking counterparties for small transactions (unless they generate these automatically from their matching of assets and liabilities).

It is much more likely that the vast majority of trading will be in standardised clusters of tokens, defined by well-recognised templates. This is the nearest we get to 'asset trading' in a conventional sense, but of course, the range of standardised templates is not restricted to the types of conventional assets that we are familiar with. So new tradeable products can be easily defined and launched.

A likely pattern is that participants will trade standardised templates for the majority of their trading activity, but will focus effort on more bespoke clusters where these are of high value to them in managing the

[112] Without question, the speed and scalability of current Distributed Ledger networks need to improve. Inter-operability between DL networks needs to mature and standardise. DL technology needs to embrace and support the location of smart contracts on tokens, and deliver value-neutral fractionalisation.

profile of their forward flows, and therefore refining their match of assets and liabilities. This parallels an efficient dealing room in the conventional world, where the dealers automate standard, liquid trades, and spend little resource on them, while focusing significant time and energy on non-standard, awkward and illiquid trades.

Technical Logjam

There is much public concern about the lack of scalability and the restricted performance of current DL platforms. Blockchains are processed serially, and as blocks get bigger, the mining and consensus processes become more and more prolonged. With Bitcoin, for example, able to process only 7 transactions per second[113], investors started paying to move up the queue. When Bitcoin transaction volumes rose sharply in early 2018 and late 2021, average fees rose by a multiple of 150-250. Permissioned networks, such as the exemplar network defined in this paper, solve that problem.

It is clear that, in a smart token-based, distributed ledger network of any size, there will be a lot of flows, and therefore a lot of smart tokens pledging and implementing those flows. For some critics, the sheer volume of tokens makes the problem seem too hard to solve.

We certainly need significant storage capacity for all these tokens, and the Distributed Ledger network, like any other, needs bandwidth to keep data at the relevant nodes in constant alignment. However, we should take account of two factors before becoming too concerned about the volume of flows. First, the flows that we define as smart tokens would take place anyway in a conventional, asset-based trading and management platform: they are just not as uniform or transparent, and are generated over time, based on the terms, conditions and lifecycles of assets. Secondly, the volumes that worry us so much in investment are minor compared to the volumes managed in other application areas like telecoms and astronomy, where record counts in billions are commonplace. Scale alone cannot be an objection: capacity in the technology is the issue to solve.

All the settlements of equities, all the income and redemption flows of bonds, all the movements of collateral and all the value exchanges of swaps will be represented somehow and at some time, whatever platform and model we use to represent them. The smart token model does not increase the number of flows that need to be represented. Rather, it generalises the representation of flows so that most behaviour is represented and managed through smart tokens, which are all of essentially the same uniform pattern. So while technical implementation is of central importance to digitisation, the processing of transactions is rationalised in the smart token model, and the business systems that remain at the nodes are simpler too, and more standardised. Smart tokens make the technical representation of investment more straightforward, not more complex.

There are opportunities to tune the efficiency of the platform at a technical level. The 'location = ownership' view set out in this paper is a powerful model, giving full effect to the functions and control of smart tokens and IOUs; however, it does not stipulate how the ledger design is implemented technically. In modern computing environments, it is common, and often helpful, to present a deployment view to applications that is different from their physical implementation[114]. It could well be that the most efficient design does not directly implement smart tokens as described. It could, for example, physically immobilise and index the tokens[115], and even share code between them where they are clones. The technical implementation can achieve such efficiencies as necessary, so long as the implementation model for the participants is clean, and the logic that they perceive follows the behaviours and capabilities of smart tokens as set out in this paper.

[113] See: https://www.bitpanda.com/academy/en/lessons/the-problem-of-scalability-in-the-bitcoin-network/

[114] Kubernetes is a good example. This is an open-source container-orchestration system for automating computer application deployment, scaling, and management. See https://kubernetes.io/

[115] This is essentially the implementation model in a blockchain context where the tokens do not move, but are associated with an address which can change.

Regulatory Roadblock

It is an obvious objection to the replacement of an established model that regulators will never allow it. The objection has force, but market governance should not allow it to be used to prevent progress from an inferior model to a superior one.

It is an obvious and undeniable fact that regulation is drafted in the context of the dominant operating model in the regulated jurisdiction, at the time that the regulations were drafted. That operating model will almost certainly include regulated entities, roles and constructs that do not exist in the replacement model. Conversely, the new model will likely instantiate objects and activities that have no place in the current model.

Regulators who are actively engaged in the evolution of rules for digitisation have obvious concerns (inter alia) about decentralised models, about open ledgers, about unconstrained peer-to-peer trading, and about permissionless structures. There is a long way to go before consensus is reached on the appropriate form of regulation for a digital world.

In the very short term, regulators can (and do) try to insist that the processes, roles and controls implemented in any new model should adhere strictly to the regulations defined for the old model. This has been the standard approach to security tokens, though some jurisdictions (such as Gibraltar and Liechtenstein) have passed specific token laws. Using existing securities laws would be fine if the issuance of digital assets on-ledger was just the same thing as issuing conventional assets off-ledger. But it's not, as we have seen. In anything beyond the shortest term, this approach will lead to inadequate regulation of new entities and the imposition of unnecessary rules, applicable to now redundant roles. The result will be the stifling of innovation and the perpetuation of inefficiency.

The mission statement of the FCA[116] in the UK includes a commitment to support innovation, competitiveness and efficiency. It says that its published strategy "highlights the importance of a strong and stable financial system which supports business growth, innovation and competition and ensures UK markets remain attractive to both inward and international investment".

The Roman Catholic church was opposed to the migration from Ptolemy to Copernicus on theological grounds, and initially there was a lack of evidence that heliocentrism was correct. That evidence built up, but the theological objections remained. Regulators are not theologically constrained, but they do require evidence before endorsing innovations that might affect investors and financial stability. That evidence is now accumulating. With their commitment to innovation, competitiveness and market efficiency so explicit, regulators cannot allow themselves to be the reason why change cannot happen. They will have to address the regulatory changes required to facilitate transition from our current inadequate representation of trades and assets to a demonstrably superior model.

To counterbalance concerns related to regulation, there is a significant upside for regulators in the smart token model. The inherent transparency of the participants' forward flows, whether inbound or outbound, can make a significant component of regulatory reporting redundant, if the regulators themselves are prepared to become network participants and subscribe widely to transactions. Additionally, there is no need for different reporting media and standards for different asset classes / products, as they all comprise the same underlying flow model, so the regulators will not need to consume these.

Legal Barricade

An objection with some truth behind it is that current legal structures are at odds with the smart token model. Indeed, we saw earlier in this paper that the existence of a range of 'things' that we can own, trade and have rights to is very convenient from a law-maker's perspective. In our model, there is no 'range of things' to define (there are no discrete asset classes, after all) and there are just two fundamental legal constructs in need of definition: title and pledge.

We can see this as a problem if we choose to, and there is unquestionably work to do. We need clear definitions of the rights and obligations of issuers / pledgors and recipients, and the sanctions where pledges are defaulted on. Greater clarity is also required on the notion of title in a tokenised context. While acknowledging the task in hand, it is just an inevitable consequence of desirable change. Rather than seeing this as a problem, we should see it as a valuable opportunity to simplify and rationalise the laws that govern finance.

[116] Financial Conduct Authority

In the smart token model, the number of distinct entities is low, and the number of things that can happen to them is very low too. Therefore, the number of things and actions that can be regulated or defined in law is very limited, compared to the conventional model of assets and transactions. As we have seen before, there are nodes and there are tokens: these are title tokens, digital cash or smart tokens. The nodes can issue smart tokens and send them to a recipient, in an equivalent of the primary market. The nodes can hold any tokens, fractionalise them and trade them on to other nodes, in an equivalent of the secondary market. These entities and these actions should be the focus of a reworked legal and regulatory framework.

The law is there to facilitate and clarify trade, not to ossify it in outdated codifications of redundant processes and entities. If the investment business wants to change, then it would be reasonable to expect the law to follow sharply; in the case of English law at least, it has a track record of doing so.

Compliance Overload

Related to the "Regulators won't allow it" objection is the challenge that there could be countless, diverse rules needing to be encoded on smart tokens. The implication is that all smart tokens will require a full compliance engine to be embedded on them, so that they can ensure that what they do to other tokens (and to themselves) is in accordance with regulation at all times. This is alleged to make the creation of smart tokens technically impractical.

In practice, the requirement for conventional compliance restriction is at the nodes, rather than on the tokens. In particular, this impacts the editing (and therefore issuance) functions of the nodes. Guidance is required to constrain the creation of smart tokens, including their capabilities, terms and tradability, to those permitted by the relevant regulations: tokens mustn't be issued by a node that is not allowed to issue them; tokens mustn't be sold to a node that is not allowed to own them. This is a far simpler and more practical requirement than the embedding of a full compliance engine on each smart token; however, it does have an implication that reference data must exist at the node for the compliance terms on the tokens to check.

As with the responses to legal and regulatory objections above, we should bear in mind again that the smart token model achieves a very high degree of simplification. There is always an asset and a liability side of every pledge. The issuer is always the party pledged to deliver, no matter how many times the pledge is sold on. The universe of rules that can be, and need to be, defined in this model is very narrow by contrast to the constraints on conventional assets and trading. This simplification of regulation and compliance is a very impactful benefit to the new model, not an obstruction.

The most intrusive and costly regulations to implement are KYC, AML, CFT and sanctions. Issuer and investor on-boarding, and ongoing transaction screening, will continue to be a burden until credible federated approaches are implemented at network level, relieving participants of a very significant workload and constraint. While it is beyond the scope of this paper to explore these approaches, it is clear that digital identities can make a major contribution.

Trust Trauma

Without third party intermediaries creating trust between transacting parties, it will be a common concern to establish exactly how those parties can come to trust each other directly. The fact is that trust can, and should be established without intermediation.

The smart token environment is, according to the model proposed in this paper, a permissioned network. There will be an on-boarding process run either by the network operator, or ultimately by federated KYC service(s) operating at network level. The participants are all part of a private club, whose rules include gating criteria for membership: there is a level of trust from the fact of acceptance into the club, and no need for an expensive trust mechanism or intermediary in this respect.

Ultimately, even if the trade process starts with an advertisement or IoI, issuers have to send their pledges to recipient nodes, and they cannot force acceptance by the recipient. The recipients can examine the pledge on their node, and can reject it or hold it. If they choose to hold it, then the issuer is committed to the pledge and cannot withdraw. The recipient has the smart token on their node, and knows that it will self-execute at the point that its conditions are met. So the recipient can have trust in the obligation on the issuer; all is well, unless the issuer defaults. If the issuer's delivery (or delivery from the settlement node that the parties agree to use for net settlement) is underwritten by a liquidity provider, then that risk is mitigated too. The recipient does not represent any pledge to the issuer, so the issuer does not need to trust the recipient – other than trusting that the recipient cannot corrupt the terms of the pledge.

Trust has to be supported by a robust legal framework around pledges and title: the parties to a pledge, and holders of title to an off-ledger asset, need to be certain of their rights and obligations.

Security and Resilience Slump

Operational resilience poses obvious questions for any asset and transaction model: what happens when something goes wrong? Who can we sue if losses are incurred?

The most apparent threats to the secure operation of the network include:

1. The network could fail physically; trades are delayed and pledged deliveries are missed as a result of downtime;
2. The network could fail logically; smart tokens are not routed to the correct nodes;
3. A smart token could be badly coded, and its self-execution could fail; consequently, the settlement process is derailed;
4. A settlement node could fail to compute net deliveries accurately and / or fail to make the correct net deliveries;
5. Liquidity could not be delivered as committed; a gross or net settlement fails as a result;

While the smart token model implies a reduction in the need for intermediaries, there are still entities who own components of the logical and physical infrastructure, and who have responsibility for the delivery of their services. They would be responsible for the failures above:

1. The network operator[117], delivers the network as a service, and will have agreed obligations to, and agreed service targets with the participants;
2. The provider of the Distributed Ledger platform[118] has responsibility for the integrity of its own logic, and will have an obligation to ensure that it continues to operate;
3. A smart token is the creation, and responsibility of the issuer, who is accountable for the quality of coding. This means that they must test the logic of their code, and they should develop trusted templates for reuse;
4. The operator of a settlement node[119] is responsible for the integrity of the netting computation for any settlement window, and for the completeness of net delivery;
5. Liquidity providers[120] are responsible for meeting their obligations in the case of issuer default, in gross or net settlement; failure to do so will be a breach of their own pledges.

In addition to such threats to operational resilience, there are the standard hazards of cyber-crime: data theft, network penetration / hacking and digital fraud are among the most apparent. Fortunately, we inherit the benefits of Blockchain and Distributed Ledger into the smart token model. Blockchain provides us with a data locking mechanism and immutable data history, which together deliver solid protection. The real-time data replication inherent in DLT platforms maintains multiple copies of the ledger (or multiple subsets in a Corda-like ledger), spread around the nodes. This makes both the detection of fraud, and the recovery from corruption, much easier than in conventional technologies. The replacement of trusted intermediaries with distributed control eliminates a focal point of weakness, a single point of failure and a single, central hacking target.

None of these mitigants is perfect, and it would be reasonable for a critic to point out that we are still dependent on the rigour of technical security and the quality of coding. However, making this a reason not to move to a better model makes perfection the enemy of pivotal improvement.

Vested Interest Veto

A natural defensive reaction to a new model is to defend the status quo, and this becomes more acute when there are revenues to protect. The smart token model impacts a wide range of existing market participants, from software providers, through asset servicers, custodians and payment banks, and on to market infrastructures and brokerage firms. Sharp critique can be expected from a broad front.

[117] The network operator should be a trusted entity, capable of running large scale platforms and networks, such as a market infrastructure provider

[118] This may be, for example, R3 for Corda, or ConsenSys for Quorum

[119] Settlement nodes may be run by the network operator, or by specialised service providers

[120] Acting as a liquidity provider is a natural role for a banking entity

Inertia is another force that argues for the status quo. Senior managers tend not to be enthusiastic about disruptive change, particularly if they own large amounts of stock and options, and can look forward to generous pensions and retirement bonuses. Others will be more visionary and engaged; however, large incumbent firms consciously electing to do nothing must be anticipated as a risk.

Alongside the threats to the existing operating model and its participants, the smart token model offers new business opportunities. Like any innovation which simplifies an industrial process and transforms its economics, the new model opens up a potential expansion of the market, facilitates new products, and opens the door to new populations of consumers. Winners will emerge from those who embrace it.

A good example, if not a perfect parallel, is what happened to the options market after Myron Scholes and Fischer Black came up with the Black-Scholes option pricing model in 1973. The model was not perfect in any sense (like heliocentricity), and depended on a set of unrealistic assumptions. However, it (like heliocentricity) was much better than the ideas that preceded it. It transformed a limited, informal market with speculative pricing, and facilitated the launch of the Chicago Board Options Exchange in the same year, trading standardised stock options. Options became more respectable, became widely invested and exploded in volume. Moving to a better model pays off commercially.

Any new model needs detailed critique, so there is nothing wrong with that, although constructive critique is likely to be mixed with some more Luddite[121] reactions. The fact of opposition (and / or obstruction) is not itself a reason to pull back from the definition of a new and superior model. We need to pin the target to the wall, then look at the best way to get there, and then work out who is best placed to be part of the journey, and who can deliver as part of the solution.

Benefits and Consequences of the Smart Token Model

The consequences of the smart token model proposed for digital issuance are radical, and hugely beneficial, on both sides of the P&L account. We can deliver new and much more flexible financial products, while simultaneously achieving an order of magnitude reduction in operational costs and complexity. System architecture becomes simpler, more standard and easier to change, while the requirement for external service provision diminishes. Liquidity, trading flexibility, risk and liability management improve, while security data maintenance, asset-servicing and settlement management are ultimately eliminated.

The notion of a business system, which defines the capabilities, operating model and constraints of the business that it supports, dissipates with the smart token model. The only things that move are tokens, and they make themselves move, in ways that are defined by smart contracts written onto the tokens themselves. The business platforms become much simpler, much less heavyweight and largely undifferentiated. They act as receptacles for tokens. Their major active capabilities are in permissioning[122], and in the minting and burning of tokens, the editing of the pledges and conditions that the tokens contain, and the initial transmission / receipt of tokens in the ordering process. Beyond this, the tokens manage themselves. Any node can mint any pledge that it so chooses, within any regulatory or governance limits that constrain the node owner.

In conventional business systems, a business decision to accommodate a new asset type, launch a new product or address a new jurisdiction generates a requirement for change to the supporting business system. This is often time-consuming and costly, requires changes to underlying data structures, and new maintenance routines as well as new business functions. Together, these act as a constraint on the driving business initiative. In a smart token model, a new business initiative requires only the definition and issuance of the new tokens that encapsulate the new scope of business. Change can be quick. It is good news for business generation, but bad news for conventional business analysts and system designers.

[121] Luddites were a faction of manual textile workers in 19th century Britain, who resisted automation in their industry and broke up new machine looms.

[122] The most significant permissioning function at the nodes is to define the circles of interest that enable other nodes, and also smart tokens, to have visibility of tokens held on each node

The benefits of trading, valuation and risk management at pledge / flow level are substantial. Valuation reflects risk at all times, while the lowest level of risk measurement is the individual flow level, rather than the instrument / holding level. Asset owners can buy and sell individual and fractionalised pledges, to achieve a precise match to liabilities by flow, rather than an approximate match by instrument, and no longer need to refine these approximations with expensive derivative contracts. The liabilities and assets of the asset owner can both be represented by tokens on ledger, and visible to the owner at all times, so there is no need for separate asset and liability management platforms.

The issuer of a conventional bond has exactly the same obligations as the issuer of the smart token equivalent, but has all the work (or cost, if they use an agent) of registry, settlements, entitlement calculations, payments and reconciliations to do. Smart tokens take these away: they make the issuers' lives much easier, without adding to their risk or obligations. Even the messy processes around corporate actions and income are simplified and automated by self-execution. From an issuer's perspective, smart tokens are all benefit and no cost.

From the recipient's point of view, smart tokens also take away work, trouble and cost, without increasing risk. The beneficiary of a pledge no longer needs to compute, agree or reconcile movements with the issuer. The beneficiary's forward flow of receipts does not need to be computed or projected, as they are visible to them at all times. The beneficiary therefore has no need of a treasury or forecasting system to generate a forward cash ladder. Nonetheless, their inbound flows arrive on time, and without work or intervention on their part.

Other areas of conventional business architecture are simplified or transformed. Order management ceases to be a discrete island of functionality, as do treasury, collateral management and asset / liability management for asset owners.

There is 100% commonality in the way that digital assets are represented and processed. Intractably difficult asset classes, and particularly OTC derivatives, become no harder to handle than any other instrument: they are just a cluster of pledges, like anything else. They are represented exactly as they are, along with any collateral management terms, and self-executed in a standard fashion. This commonality of representation allows a single operating model to be implemented across all digital assets. Combined with the inherent transparency of forward flows on-ledger, this common operating model eliminates a significant proportion of regulatory reporting, and makes the regulators' life easier too.

In addition to the reduction in regulatory reporting, there are major compliance benefits which accrue because of the common operating model, the replacement of multiple, complex processes with fewer, simpler processes, and the reduction in the number of intermediaries. For example, the new model mitigates settlement risk. Consequently, it requires no Central Settlement Depository, so the implementation of the settlement discipline regime of CSDR, which is devouring resources and budget across the market, would be redundant. The SFTR securities finance regulations would be redundant too, as securities finance transactions are no different from any other in the smart token model, and they exhibit the same complete transparency.

The compass of what can be traded expands to the fullest extent possible: every flow of any kind is a tradeable entity, rather than just the wrapped-up bundles that constitute conventional tradeable assets, offering choice, precision and liquidity to the manager and to the trader. New tradeable products are quick to define and easy to launch.

The maintenance of a security master database is eliminated, as the behaviours of the token clusters (that are the nearest equivalent to assets) are defined in the smart tokens themselves. Any node can issue any pledge it chooses, so (subject to legacy regulation) there is complete freedom in the 'assets' that may be defined. The boundaries between asset classes will erode and ultimately disappear, giving complete flexibility to capital issuers and asset owners to negotiate structures which suit both precisely.

Building on the progress proposed in the first part of this paper, we inherit the generalised benefits of distributed ledger: the eradication of messaging and the elimination of reconciliations. We further exploit the benefits of tokenisation, and the singular representation of transactions and settlements to deliver atomic settlement and a self-maintaining registry. We now add to these the radical benefits of self-executing smart tokens, and we deliver a digital model which is both self-settling and self-servicing. Settlement management, and asset servicing, as discrete activities, are therefore no longer required.

Conclusion

This paper does not put forward a classic blockchain-based disintermediation play. We are not targeting specific institutions and demanding their extraction from the process. This is a play about getting the model right for digital asset issuance and transaction. When we get the model right, then we can think about what, and who, is needed to give the best effect to it in live operation.

Any representation of reality is a model, and not reality itself, however familiar the model might be. If a model is a flawed representation of reality, then making it fit will require a string of exceptions, patches and workarounds that all add to its cost and undermine its integrity. That is the situation we find ourselves in with our current model of assets and transactions: it is familiar and comfortable, but wrong.

Conversely, if you are brave enough to represent the world in a way that more accurately reflects what is actually going on, then the rewards are substantial, even if it means letting go of your favourite delusions. Get the model right, and it becomes much more straightforward to capture and manage the behaviours of critical entities, and the exceptions, patches, workarounds and inefficiencies evaporate. Accepting that the Earth, and humanity on it, were not the centre of the Universe was tough, and challenged religious dogma as well as human egotism. Once evidence built up sufficiently to justify it, ditching these comfortable, familiar ideas released explosive progress in astronomy. Evidence is building up in our world too, that the familiar model of assets and transactions is obsolescent. Replacing it with a new, digital model would release explosive growth in investment.

We have seen that a dependence on assets as coherent and persistent things is not helpful as the basis for a model of digital investment. A generic, compelling and efficient model is entirely possible if we abandon that preconception. Simplification of the issuance and operating models requires that we deliver a wholly common approach at the flow level, and build up any necessary composites from there. Smart tokens provide us with an alternative digital flow model, and it is strikingly more powerful and more generalised.

We cannot eliminate 'things' from our model completely, and even in a fully tokenised model, there will still be title tokens referencing assets and cash off-ledger. This is not a wholly bad thing: indeed, we actively want to be able to tokenise and fractionalise off-ledger illiquid assets, for the reasons articulated in the first part of this paper.

However, where there is no need for us to enforce title to an off-ledger asset, then we should avoid it. The assumption that there has to be an asset that we can own as part of our transaction model is a dangerous trap. What can be only on-ledger must be only on-ledger. If pledges are adequate, then that is all we need, and the model becomes simpler and more generic as a result. Occam's Razor[123] applies: what can be explained with fewer entities is explained in vain with more. Or "Keep It Simple, Stupid".

While it is easy to imagine a better world, it is much harder to build one. However, if the model described in this paper is anything close to correct, then we now understand how to transfer value through time at much lower cost. That will not only make the capital markets more efficient: it will make our economies grow faster, to the benefit of employees, consumers, pensioners and taxpayers.

The smart token model provides us with a generalised and wholly flexible approach to investment that crosses current instrument class boundaries. The technology and the designs are there to achieve it. It presents us with the opportunity to simplify our world, and to convert processes which are currently challenging into standardised, self-actuating events. The result can be dramatic savings in the cost of investment and a dramatic reduction in the complexity of investment. We should take that opportunity with both hands.

The first part of this paper put forward five rules for the efficient digitisation of transactions.

1. Have one shared transaction record, not two;
2. Immobilise conventional assets and cash;
3. Make agreement, recording and settlement of trades simultaneous;
4. Make the trade record and the trade itself the same entity; and
5. Ensure that the trading parties can trust each other.

[123] William of Occam 1287-1347: "Non sunt multiplicanda entia sine necessitate", which translates literally as: "Entities are not to be multiplied without necessity". This principle in the scientific method is known as "Occam's Razor".

The second part of the paper has focused on digital assets and their issuance model. It has urged that we should get the model right, representing investment as it really is, not as we have always seen it. We have added another five rules, this time for the efficient issuance of digital assets:

6. Issue tokens at the flow level, not the asset level: represent digital assets as clusters of tokens pledging future flows (and physical assets as title tokens);
7. Transfer intelligence from conventional business systems and conventional data structures onto the tokens: make them smart;
8. Make the smart tokens self-actuating, self-executing and self-controlling, such that their triggers, their capabilities and their constraints are all coded on the tokens;
9. Make the tokens individually tradeable and fractionalisable, so that trading can be at the flow level and below; and
10. Measure value and risk at the level of the individual tokens, and therefore of the flows, not of the assets.

These are not quite the 10 Commandments, but they are 10 very powerful rules for real digitisation, and allow us to represent all digital assets and all digital trades in exactly the same way. Everything is about flows of tokens on-ledger, and those flows are controlled by the tokens themselves.

We can no longer achieve a step change in the economics of investment through tinkering changes and tactical improvements to our current investment and trading processes, or how we resource them. However, if we follow these rules and represent digital assets and transactions rigorously and accurately, then we can maximise the delivery and benefit of digitisation. Real digitisation can facilitate a step change in the cost of investment, can make investment businesses more agile and more profitable, and can give our end clients products which more precisely meet their needs.

We have a responsibility to pursue that with energy and commitment.

The constructive actions that need to be taken to move us to an optimised model of digital issuance and transaction depend on who you are. So this call-to-action asks for different actions from each of the main players.

Regulators

Move beyond the current conviction that digital assets should behave in the same way as conventional assets, be managed by the same entities, and be subject to the same rules and controls. Set out to evolve regulation which is appropriate to the optimal, flow-based model of digital assets and digital transactions set out in this paper. Become enthusiastic about the prospect of significant regulatory simplification as a result of a radical reduction in the number of entities and complexity of processes involved in financial products. Initiate design work on direct network access as an alternative to regulatory reporting, and consider becoming a participant in digital networks. Define the regulatory treatment of federated KYC / AML services, operating at network level, as an alternative to the prescribed responsibilities of individual regulated participants.

End Investors

Demand of your financial product providers that they articulate how they will deliver digital products that maximise choice and minimise cost for you as consumer. Write to your MP, demanding that the opportunity of digitisation is exploited to the full in our market, and to the benefit of end-investors.

Asset Owners

Work with capital issuers to establish the best way to communicate your demand for assets which more precisely and efficiently meet your flow requirements. Pressure your asset managers to go beyond conventional LDI, matching your inbound and outbound flows, and structuring fractional trades around these, rather than just running asset inventories on your behalf.

Capital Issuers

Make a start on the issuance of digital assets in an optimal form, purely on-ledger, rather than in conventional form or as title tokens. Be enthusiastic about the opportunity for issuance which meets more precisely the requirements of your asset owner counterparties. Band together to agree standards for digital issuance, and work with the regulators to ensure that these are as secure, or more secure than their conventional equivalents.

Central / Commercial Banks

Get on with CBDC. There has been lots of talk and consultation (and a few naysayers[124]), but we need to get away from off-ledger referenced stablecoins, with their requirement for tokenisation and encashment, and deliver real digital value on-ledger. We don't want the volatility of crypto-currencies, or the potentially disruptive effect of stablecoins, so this means CBDC, or at least commercial bank-issued e-money. Cash needs to be, and stay on-ledger.

Business System Vendors

Examine the consequences of the smart token model for fundamental systems architecture. Instigate designs for the templating, editing, issuance, transmission and burning of smart tokens, including compliance and triggering conditions. Determine the architecture required for self-actuation of smart tokens, and the interaction between smart tokens and other tokens whose movements they control. Design facilities for 'seeing the full picture', for finding liquidity, for the forward matching of inbound and outbound flows, for risk aggregation, and for the valuation of flows.

[124] See "House of Lords Committee Sees 'No Convincing Case' for UK CBD" - CoinDesk Jan 2022: https://www.coindesk.com/policy/2022/01/13/house-of-lords-committee-sees-no-convincing-case-for-uk-cbdc/

Custodian / Corporate Banks

Investigate the opportunity to deliver secure digital custody services to the network, both as private key management and off-ledger storage. Plan to deliver liquidity on-ledger, both as a liquidity-enhancing service to investors, and as a network-level service underwriting settlements. Consider the impact of flow-level transactions and smart tokens on securities financing transactions and collateral.

Payment Banks

Develop services around non-CBDC cash-on-ledger, pending the introduction of CBDC. Establish a regulated model for the operation of a cash exchange, tokenising and de-tokenising fiat currency into and out of stable tokens, as a shorter-term alternative to native cash on-ledger. Work out a regulatorily safe approach to yield enhancement for clients who chose to retain fiat currency as a preferred medium, through short-term deposits, rehypothecation or another technique.

Asset Managers

Work with issuers (and their advisers) in the primary market to design optimal digital assets; put pressure on regulators to evolve regulation to facilitate optimal digital issuance; put pressure on central banks and governments to deliver CBDC. Start planning for new investment products which take advantage of the opportunities presented by digitisation, focusing on products which meet your clients' specific flow requirements, and encompassing hybrid market / principal-traded, digital funds.

Broker / Dealers / Investment Banks

Investigate the delivery of a network service as the provider of a smart matching / market node. Seek consensus on the best mechanism for price formation in this context. Work with primary market capital issuers and asset managers to design optimal assets, and to develop efficient approaches to asset-sourcing and demand matching at flow level. Work with peers to develop standards for IoIs and advertisements in a smart token context.

Outsourced Service Providers

Recognise that asset servicing, income, cash management and transaction management services will diminish. Investigate the many new opportunities for value-add services at both network and node level. These include digital identities, federated KYC / AML, the facilitation of on-ledger collateral transfer, the operation of nodes on behalf of issuers, investors and funds, and the management of a settlement node.

Distributed Ledger Platform Providers

Address the changes needed to your platforms to accommodate and support the capabilities defined in this paper. In particular, consider strengthening your approach to smart contracts, token management and fractionalisation, so that smart contracts can be attached to tokens, tokens can self-actuate and self-execute, and tokens can split themselves into fractions on a zero-value exchange basis.

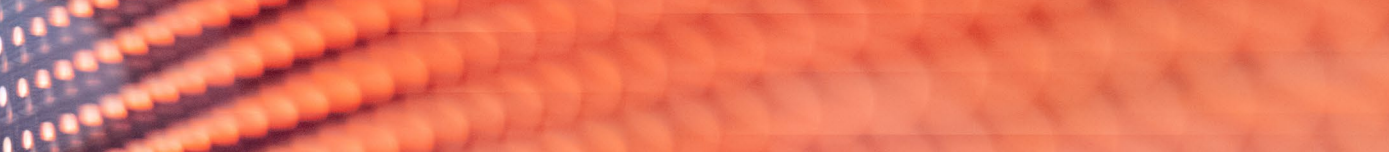
Industry Associations

Create working groups to investigate the impact of digital issuance. Actively seek to promote debate on the optimal form of digital issuance, to reach consensus on the most appropriate issuance model and to define the best underlying operating model. Encourage publications, and organise round-tables and conference events focused on the subject. Provide facilities for early technical prototyping.

Financial Market Infrastructures, CSDs, SSI Databases, Order-Routing Networks, Payments Utilities

Recognise that the new model does not require services that have been essential staples in the conventional world of assets and transactions. Explore and refine the opportunities presented for new value-add services at network level, including as operator of a settlement node and as secure network administrator.

None of this is rocket science, and (cultural stiction notwithstanding), none of it is particularly hard to move on. However, it is unquestionably hard to shift our world-view from the current, familiar paradigm, and fully to embrace the model proposed in this paper. While it may be hard, it is incumbent on all of us in the investment industry to educate ourselves about this opportunity, and to test its claims to offer a superior outcome. If much of the above happens, and the participants act with energy and commitment, then we will start to gain real momentum for radical change.



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