Four scenarios for Blockchain in Capital Markets

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This GBST discussion paper aims to provide some context to Capital Markets participants, in particular those operating in the cash equities space, regarding current industry interest in Blockchain technology. Blockchain as it could apply to Capital Markets includes a number of technologies, the most important of which are Distributed Ledger Technology (DLT) and Smart Contracts. These technologies could potentially remove many of the inefficiencies and costs inherent in today's market infrastructure. We will refer to these technologies in this paper as "DLT".

Despite the much-discussed benefits of DLT, there are challenges to its introduction which are business rather than technology related. We have looked at major changes in market infrastructure over the past thirty years in an attempt to predict what DLT may deliver, and in doing so, what the business related challenges may be.

In attempting to predict the impact of DLT, we have proposed four scenarios for its introduction into Capital Markets, with each scenario having differing impacts on the operations of participants and the market overall.

How much of what we do is based on the legacy of paper?

Thirty years ago, equities markets largely operated on the basis of paper: tickets, certificates and ledgers. It took five days or more to settle trades, mainly because paper had to physically move between counterparties. Fast forward to today and these processes have been digitised in a way that largely replicates historical paper-based processes. Trading now occurs in milliseconds and settlement takes two days instead of five or more. Figure 1 below shows some of the milestones on this journey.

Clearly, digitisation has reduced trading timeframes to a much greater extent than it has for clearing and settlement which still takes up to three days. The reasons for this boil down to two factors: the need to match and reconcile books and records between participants and the need for centralised providers to manage risk and facilitate communications. DLT seeks to solve these inefficiencies.

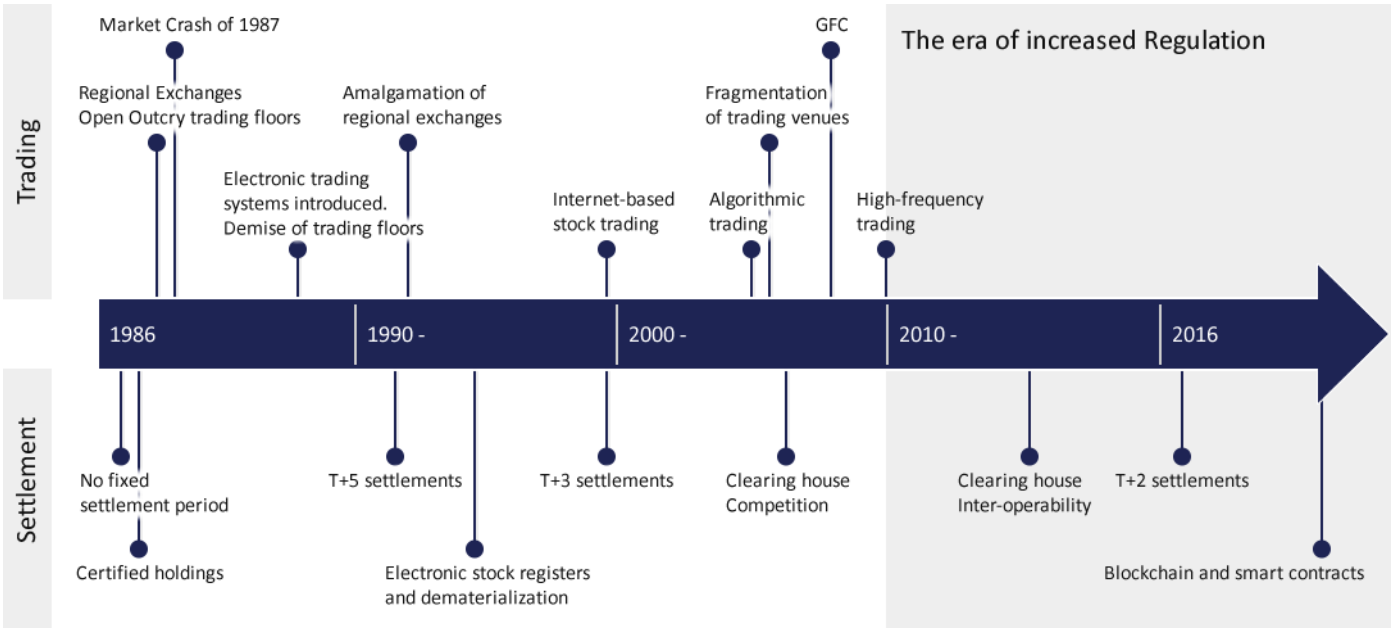

Figure 1 Capital Markets Timeline

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Can DLT solve these inefficiencies?

Inefficiency leads to cost, which can be broken down into:

- The cost of maintaining capital and covering risk
- The cost to transact.

Capital is required to offset operational, counterparty, principal and other risks. The main direct cost is the cost of capital to fund margins levied by the central counterparty, to meet regulatory liquid capital requirements and to provide liquidity for operations. Reducing the settlement timeframe to trade day or even in real-time will reduce the risk and the resulting costs. DLT is seen as a viable technology to enable T+0 and instantaneous settlement.

The cost to transact includes:

- **Trading costs** – markets, service providers and technology providers. Costs for market regulation and surveillance are also incurred.
- **Clearing costs** – paid to the CCP to reduce counterparty risk and provide settlement certainty. In addition, clearing participants require technology to manage the process and to provide internal risk management capabilities.
- **Settlement** – the costs incurred to complete the trading process by transferring the required funds and securities between intermediaries and the ultimate buyers and sellers. For institutional transactions, this is typically the cost of a DvP settlement; retail transactions typically require separate cash and securities movements. Costs for short term securities lending transactions required to cover settlement obligations may also be incurred. Settlement participants also require technology to manage the settlement process.
- **Custody** – for institutional investors, these costs are typically paid to the custodians which perform settlements and asset servicing on their behalf.
- **Indirect costs** – these cover the cost of connecting participants to the market infrastructure, banks and other intermediaries.

The question is whether DLT can reduce these costs and by how much? Much of the cost reduction would depend on changed business models rather than the introduction of different technology. DLT will only succeed with whole-sale changes in market practice which remove or greatly reduce the costs of performing these functions.

Changes in industry business models are not achieved in short time-frames – the full digitisation of markets has taken over thirty years. Likewise, Napster pioneered digital music sharing and streaming in the 1990's but it took more than fifteen years before the industry's dominant player Apple, released its music streaming service, a hybrid of traditional music purchases and streaming. DLT is an early-stage technology and it will be years before it reaches a similar state of maturity and replaces existing technologies. Until then, DLT will evolve and may merge with or be displaced by more suitable technologies.

Benefits of DLT for Capital Markets:

- Clear stock ownership – 'provenance'.
- Auditing – a non-repudiable historical record.
- Redundancy – multiple, synchronised stock ledgers; in effect, a mutualised CSD.
- The potential to reduce or eliminate clearing and CSD monopolies by using technology to automate trust.
- Transparency – regulators could be given access to interrogate the agreed record of market activity in real-time.
- Reduce or eliminate the daily stock and cash reconciliation costs incurred by brokers, clearers, custodians and others.

DLT features

- Integrated mechanisms to guarantee accuracy, redundancy and security.
- Smart Contracts – programs that run on the DLT or above it (e.g. on computers that also run the DLT). Smart Contracts can be programmed to replace the processes that currently run at clearing houses, participants' back office systems and registries. See the sidebar on page 6 for more details.
- Economic participation – models to incentivise participants to 'run the DLT' and validating transactions, running Smart Contracts, performing 'trust' activities such as issuance and managing wallets.

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DLT challenges in Capital Markets

The challenges of applying DLT to Capital Markets have also been widely documented; we list some below.

- Scalability – Existing DLT implementations struggle to approach the volume capability of existing Capital Markets platforms. The cost to share and replicate a massive DL and to perform the additional cryptographic calculations required by the model and the processing of Smart Contracts may make the model uneconomic in high volume markets.
- Fragmentation – many Blockchain and Smart Contract models are in development but very few are actually processing significant real-world transactions; likewise there are over 600 "cyber-currencies" in circulation but only one which has a market capitalisation greater than $1B USD. For wide acceptance, a smaller number of inter-operable implementations will be needed if the benefits are to be realised.
- Information Leakage – Ideally to facilitate real-time settlement, the identities of the participants are required to be known as soon as possible in the transaction process. Market models currently go to great length to anonymise participants at different points in the transaction lifecycle.
- Fat Fingers – current markets have established processes for correcting errors, resolving disputes and recovering from technology or system failures that result in incorrect data or transactions. Few, if any DL implementations consider a need for these.
- Economic Participation – For DLT to reduce cost, processing will have to be performed for less than the current charges of trusted intermediaries. A model such as BitCoin which issues new "currency" to the "miners" performing these activities would not be suitable for a DLT denominated in a "real" currency.
- Market Elasticity – the ability to short sell, net intra-day transactions and to borrow and lend stock are key enablers of retail and high frequency trading and hedge fund trading. These are significant sources of liquidity in the current model.

What is needed to succeed?

Capital markets generally seek:

- Settlement finality
- Auditability
- Anonymity at the appropriate points
- Transparency at the appropriate points
- Low latency
- Scalability
- Maximum liquidity
- Risk management or mitigation
- Richness of information – metadata.

For DLT to be successful in reducing costs, it must meet all of the above criteria or risk reducing the efficiency and utility of current markets, and must also do so in a way which either removes redundant activities or delivers a lower cost of processing than existing methods.

In some cases, particularly where there is a high level of regulation and mature market infrastructure, DLT is more likely to form part of a new architecture, rather than form the full replacement of the existing architecture – see Scenario 1. This scenario is analogous to mobile payment technology (e.g. Apple Pay) which was never going to replace the credit card companies overnight. Instead, a hybrid approach materialised where mobile payment mechanisms and credit card infrastructure complemented each other.

> "Blockchain has potentially fabulous application in the settlement realm but it's a big stretch to try and use blockchain for clearing because it means you need real-time payment systems which means Ma and Pa in Dubbo have got to make sure the money is sitting in their Commsec account before they can trade, there is no mailing in a cheque, there is no doing a transfer after the fact. For institutions, this becomes a big problem; pre-funding a transaction is often not possible because then they are exposing themselves to default broker risk."
>
> **John Fildes – CEO Chi-X Australia**

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Scenarios

We have posed four scenarios for the introduction of DLT into Capital Markets clearing and settlement. The eventual introduction of DLT will differ in each market and the use of the technology will be varied.

Scenario 1 – Technology Replacement

Scenario 1 represents a limited-disruption introduction of the technology by incumbent market operators.

Advantages	Fastest implementation
Limitations	Limited cost savings
Impact on your back office	Some impact
Likelihood	2-5 years for initial introduction

In this scenario, the technology is employed with limited change to the current business practice or participation landscape:

- A single organisation, most likely the incumbent CSD or CCP, takes the lead in terms of:
  - sourcing the technology platform.
  - designing the Smart Contracts, if any, that run on it.
  - owning or controlling the intellectual property for the platform.
  - reaching an agreement with market participants on engagement models.
  - determining the dispute resolution processes and effecting required corrections.
  - ensuring that the platform complies with appropriate regulation.
- The scope of the solution would be limited to:
  - specific instrument types served by the CSD/CCP e.g. ETOs, large value OTC derivatives, Fixed Income.
  - a single country.
  - possibly a secondary, lower volume market.
- Participants of the infrastructure would include most or all current participants including issuers, depositories, clearers, custodians, regulators and trading venues.
- Participants would communicate with the system using an API defined and controlled by the solution owner.

Advantages

The Distributed Ledger may allow for a more finely grained holding structure to be represented in the ledger.
For example, it may allow custodians to represent each beneficial owner's holding separately, but kept hidden from other participants using encryption. This would have a significant impact on markets such as the U.S. which have historically relied on nominee structures as the primary form of security holding.

Additional knowledge of beneficial owners may allow DvP settlement to be conducted directly between beneficial owners, and the potential availability of the full nominee structure inside the Distributed Ledger would streamline reconciliation processes.

The Distributed Ledger may allow for more direct participation by issuers or their agents. Using a permissioned model, issuers may be granted visibility of beneficial owner details held in the Distributed Ledger, eliminating costly and time consuming proxy processes. Issuers may be able to disseminate corporate action event information directly into the Distributed Ledger, which could be effected using Smart Contracts.

Regulators could be provided with full visibility of the data using a permissioned model. Because the data is replicated to multiple physical locations and digitally protected, there can be a high level of confidence in the data, and any tampering is uneconomical or virtually impossible.

Limitations

Because the system is still owned and controlled by the incumbent central provider of clearing and settlement services, there may not be any significant reduction in clearing and settlement fees. As the platform is not truly open, the rate of innovation available may also be limited.

T+0 settlement is unlikely to become standard practice. Certainly any new system could facilitate Continuous Net Settlement (CNS) or Real-Time Gross Settlement (RTGS) and would, subject to availability of stock and cash on both sides, be capable of completing settlements within a small number of seconds.
The existing settlement infrastructure in most markets already supports this capability and replacing it with DLT may not be justified on reduced processing costs alone. The fact that real-time settlement has not already become prevalent underlines that the limiting factors are process rather than technology issues.

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THE DEMISE OF THE CLEARING HOUSE

There has been much debate around the potential to eliminate centralised clearing in cash equity markets – replaced with a trading model where the ability to settle is validated as part of the trading process. Achieving trading that is truly free from settlement risk would require significant changes to current trading practices. A number of trading practices which currently contribute to liquidity such as High Frequency Trading, Market Making, Short Selling, Block trading and Portfolio trading may be rendered uneconomic. As such, we think that Clearing Houses will still feature in most operating models.

What would my back office look like in this environment?

Under this model, the back office environment looks a lot like it does now. Each participant will maintain their own set of records and will communicate with the Distributed Ledger using an API provided by the CSD, as it currently does. The Distributed Ledger will not maintain data on your firm's internal structure, commission accounting and distribution, profit and loss or inventory, nor will it issue confirmations and statements to clients. Funding and cover arrangements such as stock borrowing and lending may not be represented in the Distributed Ledger and would still need to be managed in a back office environment.

If the Distributed Ledger provides an intelligent implementation of RTGS/CNS settlement, this may result in less need for specialised back office functions for settlement management, however this may be offset by additional functions that might be required to ensure enrichment of transactions with additional client/counterparty information earlier in the process and to move cash onto and off the Distributed Ledger.

In a Distributed Ledger-based system, there is no longer any central computer system running the CCP/CSD operations. If you are currently a CCP/CSD participant, you may be asked or required to run one of the Distributed Ledger processing "nodes" which you may elect to subcontract to a technology vendor; under this model the cost of processing would be moved from the infrastructure provider to the participants.

How realistic is this scenario?

From a technology perspective, this is the simplest scenario to achieve because it can be implemented with few if any market structure changes.

From a commercial perspective, this scenario provides the least cost savings to the market and as such, can be seen as a stepping stone for further evolution.

Scenario 2 – The Extensible Ledger

In this scenario, Scenario 1 is extended to provide an *extensible* 'Smart Ledger'. This scenario could also be delivered by an industry association of participants.

Advantages	Platform for innovation and gradual cost savings
Limitations	Technology is unproven, large-scale market change needed
Impact on your back office	High impact
Likelihood	Possible in the medium-term

In addition to the core depository and transfer functions provided by the Distributed Ledger in Scenario 1, participants can extend the system functionality by developing Smart Contracts which provide value added services, gradually moving more and more back office processing into the Distributed Ledger platform. The system operator may still play a role in validating and approving Smart Contracts for use on the platform.

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Advantages

The key difference in this model is that the participants are able to introduce new functionality to the system on their own terms. Innovation can occur at a rapid pace if necessary.

This might involve supporting different types of transaction – e.g. a Smart Contract could be developed which will register stock borrow/loan transactions and automatically perform the margining and return processes on behalf of the borrower and lender firms. Alternatively, the platform might be extended to support equity swaps, or trading and settlement of certificates of deposit or other short term income securities.
The development of Smart Contracts that encapsulate agreements between multiple participants would need regulatory oversight or an agreed development framework.

Management of internal firm data on the platform (e.g. commission attribution, inventory or P&L) is another possibility. These calculations are currently performed in back office systems but could be moved into Smart Contracts running on the Distributed Ledger platform. How the results of Smart Contract processing would be extracted and presented to internal users is to be determined.

A marketplace could evolve for the development of such Smart Contracts with vendors competing to provide ever more powerful or flexible offerings to participants.

The traditional role of the Clearing House could also evolve in this scenario. Currently, clearing houses interpose themselves in every transaction. However, in a Distributed Ledger environment, central clearing could be performed as required – especially if some portion of the activity has been validated prior to trading – and multiple providers could compete to clear transactions, or receive a small fee for the temporary supply of liquidity to the settlement process.

Limitations

Innovation on such an open platform will require a mindset change from all parts of the industry. Participants will need to agree on how proposed enhancements will work, how the costs and benefits are distributed and will need to trust the platform implicitly.

The benefits of this scenario would have to outweigh the cost of Smart Contracts executing on multiple nodes and the costs of securing and validating Smart Contracts, which could be significant.

SMART CONTRACTS

Smart Contracts were initially conceived as programs that implement the operations defined in a contract. However, in the current blockchain architectures, Smart Contracts are simply programs implementing some business logic, stored in the underlying Distributed Ledger and executed by some nodes in the blockchain network.

Languages for Smart Contracts evolved from very limited scripting languages to Turing complete languages. This means that, potentially, a Smart Contract can run any instruction that can be executed by a regular computer. A problem with Turing complete languages is that, in general, it is not possible to determine if a program will terminate. Accordingly, one could write programs with infinite loops. To address this issue, Smart Contracts introduce the concept of "gas". Roughly, this corresponds to the number of operations performed by the execution of a Smart Contract, and consequently the amount that the party invoking the Smart Contract has to pay to the nodes that execute it. Thus, to run an infinite program, one has to pay an infinite amount of (cyber) currency.

Smart Contracts are triggered by data recorded in the Distributed Ledger, and they write the results of their computation in the ledger. A central tenet is that Smart Contracts have to be deterministic and verifiable by the Distributed Ledger, in the sense that every node in the network should see the same data. Thus, Smart Contracts cannot access data external to the Distributed Ledger. However, there might be situations where the parameters needed should be obtained from the outside world. In such cases, Smart Contracts can interface with oracle programs running on the blockchain that query the outside world and store the result in the Distributed Ledger.

Guido Governatori – Senior Principal Researcher,
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This scenario requires greater regulatory oversight than Scenario 1 to ensure that Smart Contracts behave correctly and mechanisms are in place to manage disputes or errant Smart Contract code. Regulators may initially lack the skills required to supervise a system with this level of complexity, limiting the pace at which innovations can be implemented.

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What would my back office look like in this environment?

Under this model, the back office environment could change significantly over time. Instead of each participant running their own software, some back office functionality could be executed on the Distributed Ledger using Smart Contracts which participants can licence or use on a 'pay-as-you-go' basis.

These Smart Contracts may be provided by collaborative, open-source development between the participant firms, or may be developed by third-party technology providers.

Firm-private back office software will still be required, even if only to provide a gateway between internal systems and software running on a Distributed Ledger environment.

How realistic is this scenario?

Creating a truly open and collaborative platform for key capital market infrastructure while meeting all applicable regulatory and legal concerns is a significant challenge.

This scenario appears unlikely to be achieved in the short term.

Scenario 3 – A new Global Clearing and Settlement (C&S) Infrastructure

A global consortium of brokers, banks and C&S providers collaborate on a next-generation Distributed Ledger-based C&S platform.

Advantages	Major cost savings in cross-border transaction processing
Limitations	Requires a consortium of banks and major infrastructure investment
Impact on your back office	Medium to High impact over time
Likelihood	Possible in the medium-term

The focus of the consortium is solving clearing and settlement problems in domains which are currently poorly served by existing infrastructure, or where existing bottleneck providers are providing poor value for money.

While plain, vanilla equities and fixed income clearing and settlement is not the primary focus of the consortium's work, this could easily be supported if there was sufficient demand.

Advantages

Currently, all of the world's major banks and custodians – and most brokers and investment managers – are members of the SWIFT network, which is used (amongst other things) to carry instructions for cash payments and securities settlements. A Distributed Ledger could be used to implement a "SWIFT 2.0" – which in addition to simply carrying instructions between parties, could also perform some or all of the required processing using Smart Contracts.

Registration and management of OTC transactions such as equity and interest rate swaps could be performed inside the Distributed Ledger, and processing of interbank borrowing and lending on short term money markets could be automated. Information mined from this process could provide a much more robust method for determining interest rate benchmarks such as LIBOR and BBSW.

Smarter and more streamlined processes could be established for foreign exchange and international money transfers. The additional transparency provided by a Distributed Ledger could make it easier to police AML and CTF regulations and investigate wire fraud.

Management of securities settlement between brokers and investment managers could be streamlined by allowing participants to publish their Standing Settlement Instructions to the Distributed Ledger, where they could automatically be picked up by participants for use in their systems, and automatically enlisted into Smart Contracts to deliver or receive securities. In a similar vein, a global Distributed Ledger could also provide pre-settlement matching services.

The Distributed Ledger could be used to actually complete settlement itself, by providing CSD or sub-custody functions in its own right, in a way similar to the Pan-European T2S initiative. Ultimately, one or more CSDs could outsource their function to the global Distributed Ledger.

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Limitations

Technology managed by a consortium operating at the global level is unlikely to extend into local market processing due to individual local market regulations. Therefore, it is likely that local market infrastructure will remain in place.

There are a large number of global, highly interconnected organisations and systems which need to be re-organised around new infrastructure and services which will be costly to develop and maintain. Progress is only likely to be made where:

- A majority of parties in the consortium agree on the problem areas that require attention,
- The new system can interoperate with existing infrastructure,
- A clear business case exists with real benefits achievable in the short to medium term.

Any such solution will inevitably focus on specific pain points, rather than providing a holistic solution to every clearing and settlement use case.

What would my back office look like in this environment?

Similar to the previous scenarios, core banking systems may be streamlined as functions are moved to the Distributed Ledger. However, it seems unlikely that these systems would ever be substantially replaced.

In the Cash Equity and Fixed Income space, there is likely to be little immediate change other than a need to be able to interface to these newer and smarter services for interbank communication and settlement. Some rationalisation will occur, but this will only happen once older industry standards and utilities are retired.

Broking firms who operate exclusively in the global, cross-border space and who currently utilise a network of custodians as settlement agents could benefit from a reduction in back office complexity, as a number of traditional functions of the back office could be delegated to a global interbank Distributed Ledger, especially if a global Distributed Ledger provided SSI management functionality and/or pre-settlement matching services.

Firms that currently straddle global and domestic operations may see an increase in back office complexity as a global interbank Distributed Ledger initially presents another set of services requiring interconnection.

How realistic is this scenario?

This scenario is already being considered via the R3 consortium. However, it is highly likely that this scenario will take many years to bring to fruition and will only be introduced in phases.

Scenario 4 – Uber Finance

In this scenario, DLT creates a truly global peer-to-peer network which is capable of replacing the traditional Capital Markets systems.

Advantages	Highest cost savings and efficiencies
Limitations	Likely to require sweeping regulatory change and major infrastructure investment
Impact on your back office	Very high
Likelihood	Likely in test cases in the short term and possible to become more mainstream in the long term

Facilities are provided for the issuance of digital assets using crowd funding models, direct relationships between issuers and security holders as well as trading and settlement, operating on a risk-free basis. The platform is open and easy to extend to cater for new use cases.

Initially operating as a curiosity, it is increasingly adopted as a mainstream platform for investment.

Advantages

Breaking down barriers between issuers and investors, and allowing for trading and settlement between investors directly, removes layers of financial intermediaries and fees and could substantially reduce the cost of participation.

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Such a system would make it much easier to raise capital, especially for smaller firms, and could be easily extended to cater for peer-to-peer debt funding.

Limitations

Such a system is – at least initially – unlikely to comply with relevant securities regulations, which will initially limit its mainstream use. Left unregulated, it may attract undesirable or fraudulent activity.

Existing issuers are unlikely to participate, as they are already part of the established securities market infrastructure.

It may be difficult to design an incentive model that motivates participants to share the costs of running the network and make it commercially sustainable.

While true peer-to-peer markets are attractive in theory, in practice; many participants will require assistance from an intermediary, who will need to charge a fee for their service. As the popularity of the service increases, more participants will be corporations rather than individuals. Ultimately, it may not look or work very differently to currently models.

What would my back office look like in this environment?

A key advantage of a system like this is that no back office system is required to participate – simply a piece of open-source software which can be installed in the cloud, on a PC or a mobile device, which will provide access to the most commonly required functions.

However, unless this model becomes the norm, firms in the traditional broking and investment management space are unlikely to see significant changes in their system environment with this new platform, ultimately resulting in one more set of infrastructure to connect to.

How realistic is this scenario?

Several technology platforms capable of providing this service already exist in some form, or are in the process of development, but it is unclear if any of them will prove to be any sort of challenge to traditional market infrastructures.

As we have seen with other peer-to-peer technologies such as BitCoin and Uber, a level of interoperability with applicable regulatory frameworks is key to moving toward mainstream adoption.

Putting it all together

Figure 2 summarises the potential impact of DLT on participants' operations.

	Scenarios			
Current Participant	**1**	**2**	**3**	**4**
Trading				
Figuration				
Affirm/Confirm				
Clearing				
Settlement – Client				
Settlement – Market				
Corporate Actions				
Broker Books and Records				
Asset Servicing/Reporting				
Lending/Borrowing				
Regulatory Reporting				
International Settlements				
Capital Raisings				

Legend

No change	Process removed	Likely to move onto DLT	Will move onto DLT

Figure 2 Possible Impact of each scenario on participants

Conclusion

We have posed four varying scenarios for the introduction of DLT into Capital Markets. We see each of these scenarios being investigated and possibly implemented across the globe with deployments being phased in over time as challenges are dealt with, subject to valid economics in each case.

In the medium term, back office systems will still be required by market participants for internal accounting, client value-add and other activities; in effect the back office system could be the entity's "wallet" which tracks and manages their assets on the Distributed Ledger.

In addition, some processing currently performed by current back office systems could be replaced by Smart Contracts running on DL's. More modern back office systems are likely to be more adaptable to this model than many legacy systems currently in use by participants.

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About GBST

GBST is a leading global provider of securities transaction and fund administration software for the financial services industry. Its customers include regional offices of the world's largest investment banks, custodians, fund managers, margin lenders, institutional and retail stockbrokers. With a recognised presence in the key equities and derivatives markets, and wealth management industries in Australia, the US, UK, Europe and Asia, our technology delivers unrivalled contemporary, reliable, scalable software solutions with effective support and customisations as required.

About Data61

Data61 is Australia's digital innovation powerhouse.

The world is changing, fast. We are in the throes of shifting to a new economic structure, an evidence-based world, where data underpins our decision-making. In the past two years, more data was produced globally than in all of history. The volume continues to grow exponentially, resulting in massive economic and societal disruption.

At Data61, we are creating our data-driven future. By combining the expertise of the CSIRO Digital Productivity and NICTA teams, we are building the world's leading data-focused research and innovation powerhouse. A CSIRO entity, Data61 provides a network of capabilities, addressing key growth areas for a data-focused world including: autonomous systems, computer vision, data analytics, digital economy, machine learning, mobile systems, optimisation, software systems, wireless and networks.