Towards a distributed ledger of residential title deeds in the UK

July 2020

Mishcon de Reya

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I. Executive summary

On the 6 March 2019 the sale of a recently refurbished, semi-detached house in Gillingham had completed. The conveyance process had taken 22 weeks to complete against an initial estimate of six weeks. Together with HM Land Registry's (**HMLR**) Digital Street (and a consortium of other parties set out at Section VII), we set out to explore how new technologies might improve the conveyance process.

We built a distributed ledger technology (**DLT**) based prototype that would enable a digital transfer of the property that automatically updates the Land Register. The term DLT refers to a broad umbrella of technologies that seek to store, synchronise and maintain digital records across a network of computing centres – see Section III for an introduction to DLT systems.

The HMLR implementation involved the creation of a DLT-based application, built on Corda, using a simplified number of transaction nodes.

The system was distributed, though HMLR retained an important role in the process by providing the single source of truth for the system to rely on when determining land title ownership for the purposes of the conveyance from time to time – see Section IV for an overview of the Digital Street project.

The project was a success – our DLT-based proof of concept took the same transaction that had taken 22 weeks to complete, and ran it through, end to end, in less than 10 minutes. Eddie Davies, Deputy Director of Digital Services at HMLR, has subsequently said that *"[DLT] should be invisible to citizens and I think what it will mean for them is a home buying process that is more straight forward, easier and less full of stress. It's an emerging technology that offers a good opportunity for the industry to explore further."*

The conveyance process is merely one (albeit significant and impactful) possible application of DLT within the real estate sector. It is likely that in the future several DLT systems will span the life-cycle of real estate assets, each of which will possess a degree of interoperability – see Section V for a high-level exploration of some of the other possible applications of DLT to the real estate sector that we are working on.

Although DLT holds great promise for application in the real estate sector, there remain several barriers to entry. These include a lack of awareness, certain technical limitations and issues, and what has been perceived as a lack of legal and regulatory clarity – see Section VI for an examination of these barriers and the steps that have been and are being taken to mitigate them.

II. Context

Real estate is one the most important economic assets for the UK economy and for millions of people living in the UK. As well as providing a significant amount of private market activity, real estate is particularly important for the national economy owing to the UK's high levels of foreign direct investment.

Land rights underpin the real estate market in the UK and are built on a well-established and long-standing body of land law. The legal and practical processes involved in transacting real estate are heavily reliant on the sharing of information between transaction parties and stakeholders, for example in relation to the target real estate asset, its conveyancing history and associated title searches. The advent of new methodologies and technologies that facilitate such information sharing in a more efficient manner can therefore have a profound impact on both individual transactions and the real estate market more generally.

Several innovations that seek to improve information sharing are in development. The benefits of such innovations are wide ranging. For example, innovations that improve the speed of information sharing between real estate transaction parties may reduce the time it takes for real estate transactions to complete, in turn increasing volumes and making possible new business models. In addition, innovations that improve the integrity of information shared between real estate transaction parties may improve the calculation of counterparty risk and better inform the price discovery process accordingly.

DLT is one significant example of a technology innovation that might be applied to the sharing of information in the context of real estate. This paper explores DLT and its key characteristics, provides a case study of a DLT application as demonstrated by HMLR in the UK and provides a high-level overview of some of the other possible DLT applications in the real estate industry.

III. DLT systems

III. DLT systems

The term DLT refers to a broad umbrella of technologies that seek to store, synchronise and maintain digital records across a network of computing centres known as nodes. These nodes each work to update the ledger as new updates (i.e. transactions) arise, and propagate the updated ledger to the network.

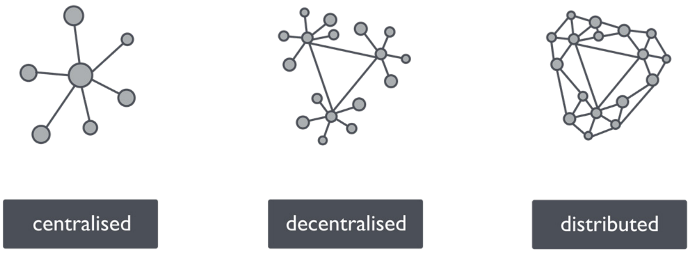

Fig 1 – centralised, decentralised and distributed ledgers

The first and most famous application of DLT remains the cryptoasset-based blockchain, Bitcoin. Based on a 2008 whitepaper authored under the pseudonym Satoshi Nakamoto, the Bitcoin source code was made open source in 2009 and was intended to facilitate the use of bitcoins as a medium of exchange. Bitcoin combined multiple innovations in a novel way and addressed several long-standing issues that hampered the conduct of business using purely digital assets.

The World Wide Web was created nearly 30 years ago and has facilitated the meteoric rise in e-commerce. The first secure online transaction and the first provision of internet banking services was conducted in 1994. This was followed by the launch of e-commerce giants eBay and Amazon in 1995, amongst many others. The e-commerce revolution has increased transaction speeds and improved consumer choice and convenience. The technology that underpins the internet does not however manifest all the properties that are required in order to conduct business across exclusively digital networks. Crucially, it lacks a mechanism to represent ownership and identity in the same way as we experience in real-world transactions.

DLT solves many of these problems by, amongst other things, addressing the 'double-spend problem' (i.e. the risk that a digital asset, which can theoretically be copied in a way that physical assets cannot, might be replicated and transferred multiple times, undermining the asset as a medium of exchange). By establishing clear protocols for how entries are committed to and synchronised on the ledger, with real-time oversight from a distributed set of nodes, DLT systems can make it possible for the function of a traditional clearing house, exchange or registry to be performed in a disintermediated fashion using only the integrity of the system itself.

1. Key characteristics

A series of mechanisms and computer protocols dictate how DLT systems work – namely, how their network participants may create, amend and synchronise records held on them. These mechanisms and computer protocols typically seek to:

- enable network participants to **exclusively** control 'their' records or cryptoassets;
- maintain a clear **chronology** of ledger entries; and
- provide a mechanism by which network participants will reach a **consensus** as to the commitment of new ledger entries and the state of the ledger from time to time, thereby ensuring a common, synchronised distributed ledger.

These components represent three key features of DLT systems. This section explores each of them in more detail.

i. Exclusivity

To enable network participants to exclusively control 'their' records or cryptoassets, many (indeed, at the time of writing, most) DLT systems utilise public key cryptography. Cryptography is a branch of mathematical science focussed on creating and solving codes to enable secure communication in the presence of third parties called adversaries.

Public key cryptography is a cryptographic system that uses two types of information (typically a fixed length string) known as keys:

- **public keys**: these may be widely disseminated and known to some or all other network participants; and
- **private keys**: these should be known only to the relevant network participant.

If a network participant wishes to send a message (or, in the case of cryptoassets, make a transaction), they would enter their message (or transaction details) together with the intended recipient's public key (or a hash of the intended recipient's public key, known as a wallet address). The network participant who is sending the message (or transaction) then 'signs' the message (or transaction) using their private key.

The recipient and the wider network is then able to verify that the message (or transaction) is genuine, by entering the public key of the network participant who sent the message (or transaction). In so doing, the message (or transaction) will, provided the public key entered is indeed associated with the private key used to send the message or transaction, be decrypted.

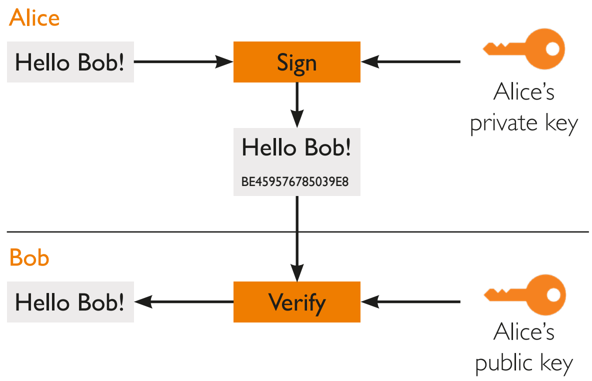

Fig 2 – Public key or asymmetrical cryptography-enabled messaging

Public key cryptography is also known as asymmetrical cryptography. This is because a message (or transaction) which was encrypted using the sender's private key, can be decrypted using the sender's public key, without revealing or compromising the security of the sender's private key.

An important conceptual point to grasp is that wallets do not contain records or cryptoassets. All that is contained in a wallet is a private key. Accordingly, when we make a new record or transaction on a distributed ledger, we do not 'send' records or cryptoassets per se, rather we send a message or transaction to the network's nodes, which then update their respective copies of the ledger accordingly.

DLT systems therefore enable exclusive ownership of records and cryptoassets by ensuring that the right to send messages (or make transactions) on behalf of a public key relies on a private key, which is capable of being kept secret and known only to a single individual. In this way, an individual can be said to 'own' (albeit indirectly) certain cryptoassets.

ii. Chronology

One of the key challenges that faces DLT systems is how to establish a clear chronology of records or transactions. As the DLT system's network becomes larger and more distributed across territories and time zones, so too does the so-called Distributed Ledger Problem become more pronounced.

> **The Distributed Ledger Problem**
> Records and transactions are passed from node to node within the network, and therefore the order in which transactions reach each node can differ.
>
> For example, say an attacker has a wallet holding 1 MishCoin (a fictional cryptoasset used for illustrative purposes only). Exploiting the Distributed Ledger Problem, the attacker may make a purchase from a supplier of goods and send 1 MishCoin to the supplier as payment. The attacker would then wait for confirmation that the supplier has shipped the goods. Once the attacker has received the confirmation, he or she would then send a transaction to another of his wallets for 1 MishCoin. Due to the Distributed Ledger Problem, some nodes might receive the second transaction before the first. Those nodes would then consider the initial transaction invalid, as the transaction inputs would be marked as already spent. If sufficient nodes to satisfy the distributed ledger's consensus protocol believed the second transaction to be the 'true' transaction, the transfer of MishCoin to the supplier would be rejected and the supplier, having already shipped the goods, would be out of pocket.

The way in which DLT systems establish a clear chronology of records and transactions is typically determined by the manner in which their ledger dataset is structured. This varies between different forms of DLT. Blockchains for example bundle ledger entries into data container structures known as blocks. These blocks are appended to the end of a chain of blocks in chronological order, hence the name. Typically, each block in a blockchain will contain a hash of the preceding block. This ensures that a clear irrefutable chronology is established and maintained.

iii. Consensus

Each DLT system node has its own view of the state of the distributed ledger at a given time. The result of this, exacerbated by the Distributed Ledger Problem set out above, is that, at any one time, there may be as many views of the present state of the ledger as there are nodes in the network.

DLT systems implement clear rules to enable their constituent nodes to reconcile differences and record messages and transactions in a harmonious fashion. These rules are known as consensus protocols. There are a number of 'flavours' of consensus protocols, each with their own trade-offs that in turn impact on the DLT system's performance and functionality.

2. Smart contracts

The first DLT system to enable the deployment of blockchain-based smart contracts was the Ethereum blockchain. Launched in 2016, Ethereum added richer functionality and depth to the DLT technology stack. DLT-based smart contracts enable not just the sharing and storing of information, but also the execution of business logic and building of reusable data models based on that information.

Broadly speaking the term "smart contract" can be used to refer to two distinct concepts:

1. The operation of a software agent.
A software agent is a computer programme that acts for a user or another computer programme in such a way as to exhibit characteristics of agency. Software agents are autonomous, or at least semi-autonomous, such that they can perform tasks in pursuit of a goal with minimal or no direct supervision or direct control.

In the context of a DLT system smart contract, the term "smart contract" refers to the way in which these software agents fulfil certain obligations, exercise certain rights, and may take control of certain assets within a DLT system. This definition is broad and imprecise, with no meaningful consensus amongst computer science academics and practitioners.

2. Legal smart contracts.
Legal contracts can be expressed and implemented in code, and recent English law jurisprudence has confirmed that DLT-based smart contracts are capable of being enforced at law.

The analysis of such contracts is specialised and can be complex, with issues relating to the operation of the smart contract, how the smart contract is expressed, and how natural language legal prose should be interpreted all requiring careful consideration.

It is important to remember that, although the automation that can be achieved using smart contracts is extremely exciting, the real value proposition comes from the underlying DLT system. Parties are only able to put their faith in the operation of smart contracts because they trust the integrity of the underlying ledger, such trust being made possible by the distributed validation and synchronisation protocols discussed above.

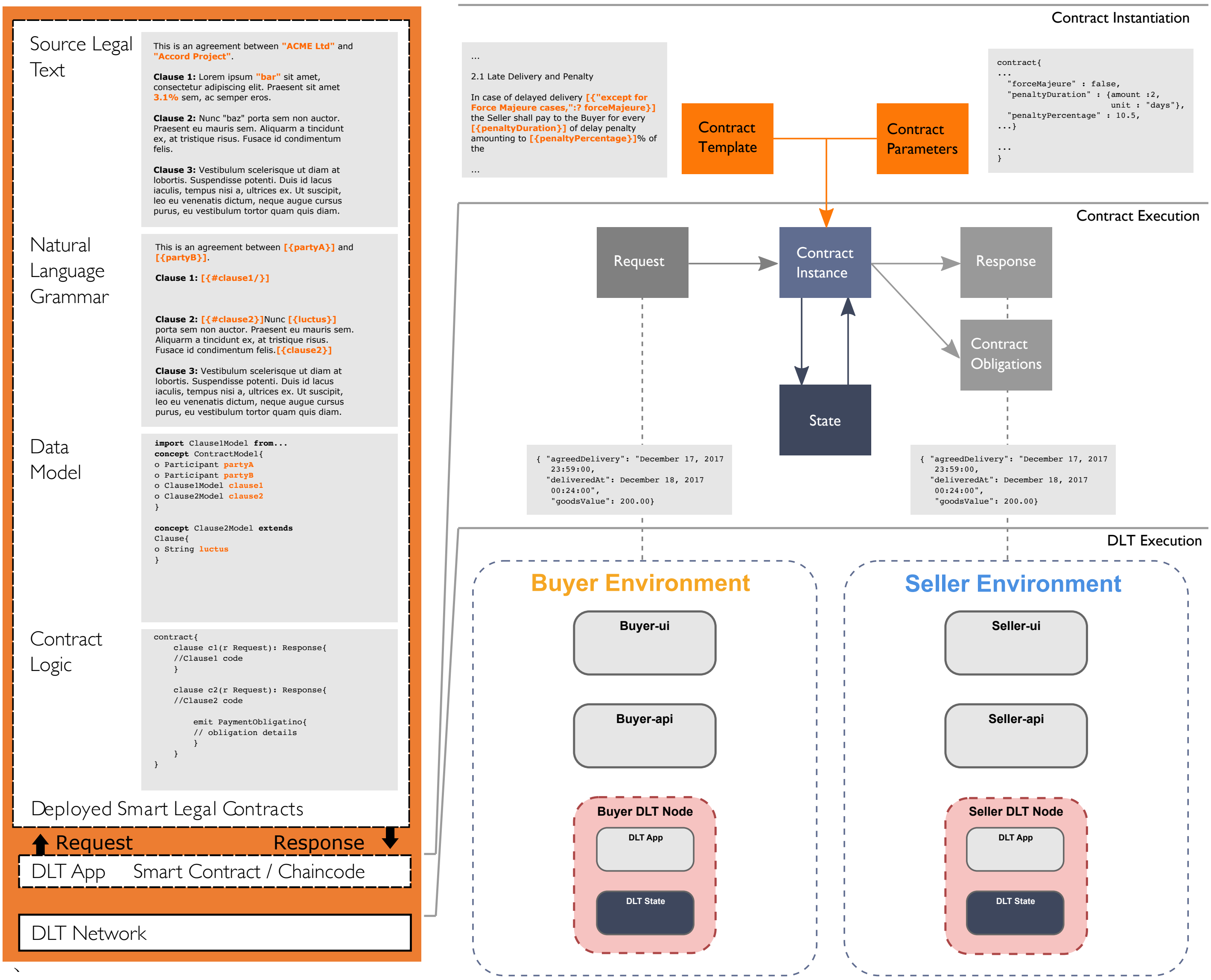

Fig 3 – deploying source legal contract text to a DLT-based legal smart contract

IV. HM Land Registry's Digital Street DLT prototype

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Together with HMLR's Digital Street (and a consortium of other parties set out at section VII), we set out to build a DLT-based prototype that would enable a digital transfer of the property that automatically updates the Land Register. In this Section we look at the application of DLT to conveyancing and the application we built with HMLR.

1. Digital Street

In 2016 HM Land Registry conducting a board-level sponsored review of its processes and published its strategy in an increasingly digital world. Among its ambitions was to *"become the world's leading land registry for speed, simplicity and an open approach to data."*

In furthering its ambitions, HMLR recognised the potential benefits of technology such as DLT and blockchain. HMLR established Digital Street, a dedicated R&D business unit focussed on exploring how HMLR might use technology such as buying and selling property simpler, faster and cheaper. Digital Street gives HMLR "a space to break away from the constraints and current ways of thinking about the home buying process as it stands today."

2. Conveyancing

The term "conveyance" refers to the legal process of transferring property from one owner to another. This process often includes the granting and redeeming of an encumbrance such as a mortgage or lien.

Typically, the conveyance process consists of an exchange (i.e. the exchange of contracts and the point at which the conveyance becomes legally binding on the transacting parties) and completion (i.e. settlement and the date on which legal title to the real estate transfers). If the transaction involves the granting of an encumbrance, it's almost certain that the lender will require that a solicitor be used for the conveyancing.

A typical conveyance involves, amongst other steps:

1. a price negotiation between transacting parties;
2. surveys, searches and pre-contract enquiries carried out by the buyer's solicitor or conveyancer;
3. the preparation of a draft contract by the seller's solicitor or conveyancer;
4. the disclosure of certain information by the seller's solicitor or conveyancer to the buyer's solicitor or conveyancer, in line with the Law Society of England & Wales' Conveyancing Protocol for residential conveyances; and
5. further due diligence questions by the buyer's solicitor or conveyancer of the seller's solicitor or conveyancer, based on the results of 2 and 4 above.

The conveyancing process is: (a) slow – in the UK it takes on average between 10 and 12 weeks to complete; (b) expensive – the manual, repetitive and duplicative nature of many conveyancing steps contributes to expensive legal fees, combined with costly searches and surveys; and (c) stressful – the uncertainty and financial stakes involved in the conveyancing process makes moving house one of the most stressful events in an adult's life, with studies linking the process to a variety of mental health problems including depression and anxiety.

The modern conveyance typically features a chain of conveyances that are each reliant on the others (and the resultant flow of monies) in order to complete. These chains mean that transacting parties may experience delays and uncertainty owing to issues in conveyances to which they have no visibility, compounding transaction parties' frustration with the process. Currently, each conveyance operates in a siloed manner to the others in the chain, with no 'single point of truth' that can reveal the state of the whole chain at any time.

3. Solution overview

The HMLR implementation involved the creation of a DLT-based application, built on Corda, using a simplified number of transaction nodes to facilitate a DLT-based transfer of a residential property.

The project consisted of three stages: first, working with the dedicated consortium to map the conveyancing user journey; second, building a prototype conveyancing application; and third, working with our consortium partners to build the distributed network in order to perform a shadow conveyance of the semi-detached Gillingham property that had been identified as our test case.

i. User journey mapping

The exercise of mapping user conveyancing journeys is a complex task that requires specialist input. Leveraging our expert Real Estate, PropTech and legal engineering capabilities we were able, together with our consortium partners, to map the legal, financial and practical conveyance processes in such a way as to be readily built on a DLT system.

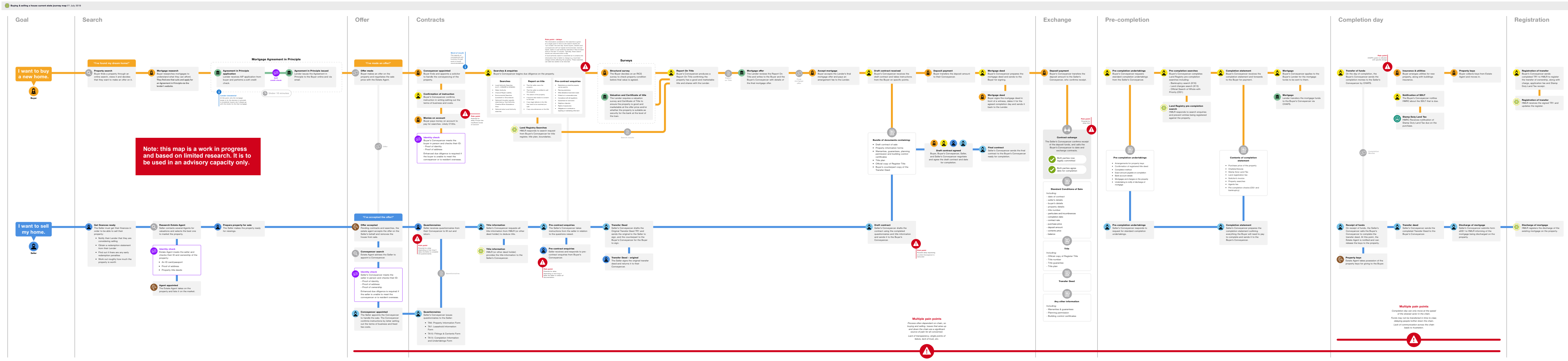

Fig 4 - a simplified user journey for both a buyer and seller in a conveyance including interactions with various counter-parties. Full scale diagram available here.

ii. Internal prototype

On completion of the mapping exercise, we rapidly produced a first iteration of a distributed application built on the Corda DLT (also known as a CorDapp) that demonstrated a basic end-to-end automated conveyance. We deployed this CorDapp across a private DLT system comprised of seven Corda nodes, all hosted within HMLR's cloud-based development environment.

Alongside the CorDapp, we also built and deployed other supporting applications including Corda-based remote procedure call clients and supporting applications to represent and act for other parties, systems and services participating in the conveyance. The CorDapp represented the real-life land titles as digital assets that could be recorded and tracked throughout their entire lifecycle. In Corda this type of asset is called a "LinearState" and is used to represent an evolving asset that changes over time. Additionally, we modelled legal agreements as LinearStates, for example to represent the sales agreement that evolved through negotiations between the transacting parties. This legal agreement LinearState was shared only with the transaction parties and their legal advisers by leveraging Corda's need-to-know basis sharing mechanism.

The internal prototype contained several states (in computing, the term used to describe a component designed to remember preceding events or user interactions) and smart contracts. These components enabled automated updates to be written to and recorded on the ledger based on data flows relating to: (1) the conveyance of a land titles; (2) the removal and addition of charges and restrictions; (3) the drafting, negotiation and execution of legal agreements; and (4) the calculation and payment of tax liabilities.

This initial prototype was based on entirely fictional buyers, sellers, conveyancers and lenders, with very minimal user interfaces. It was used solely to demonstrate the DLT systems' functionality and end-to-end flow for our team internally, as the system continued to iterate and be finessed.

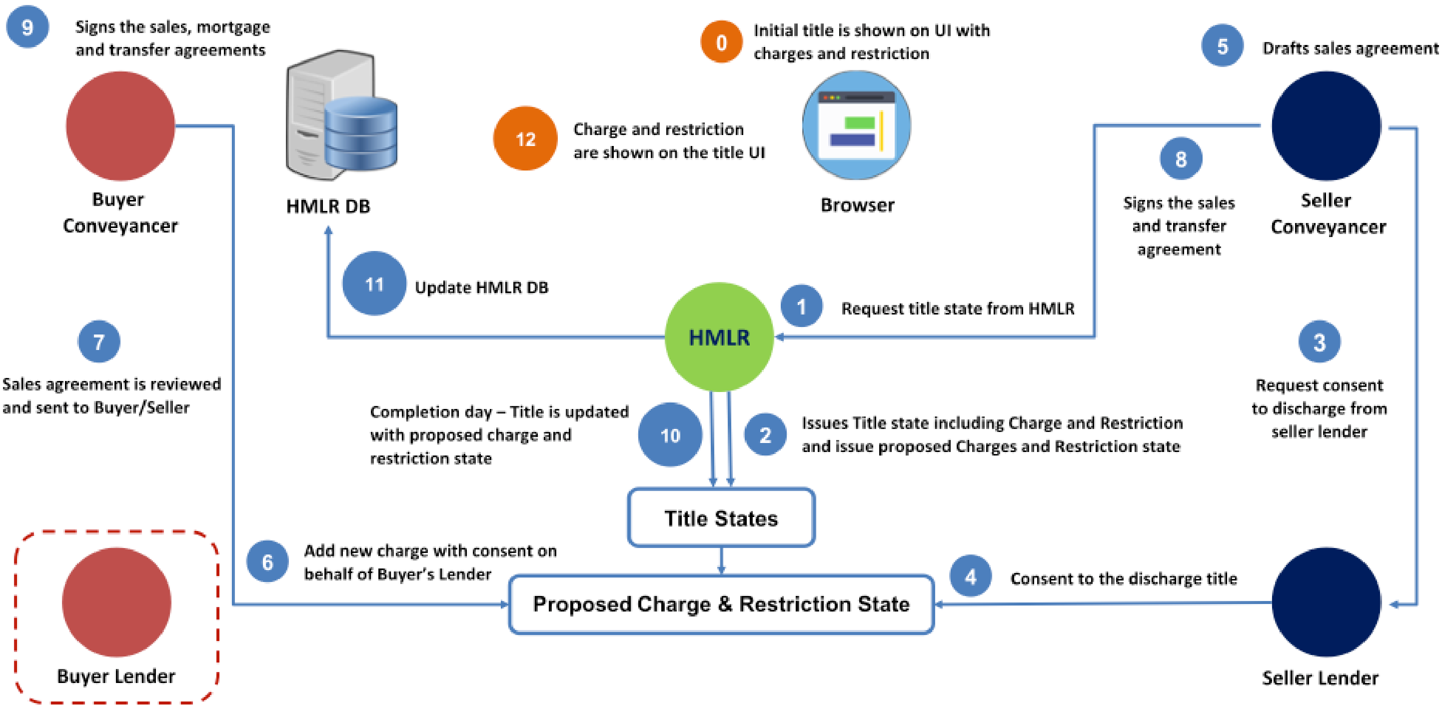

Fig 5 – a simplified data flow as part of a conveyance process

iii. Replica property transaction

On the 6 March 2019 the sale of a recently refurbished, semi-detached house in Gillingham had completed. The entire process had taken 22 weeks to complete against an initial estimate of six weeks. We deployed our DLT-based proof of concept to the same transaction – the application ran the conveyance through, end to end, in less than 10 minutes.

We established the various transaction participants as nodes on the network, each of which were able to execute smart contracts pertaining to their role in the transaction to enact changes on the ledger. HMLR retained an important role in the process by providing the single source of truth for the CorDapp to rely on when determining land title ownership for the purposes of the conveyance process from time to time.

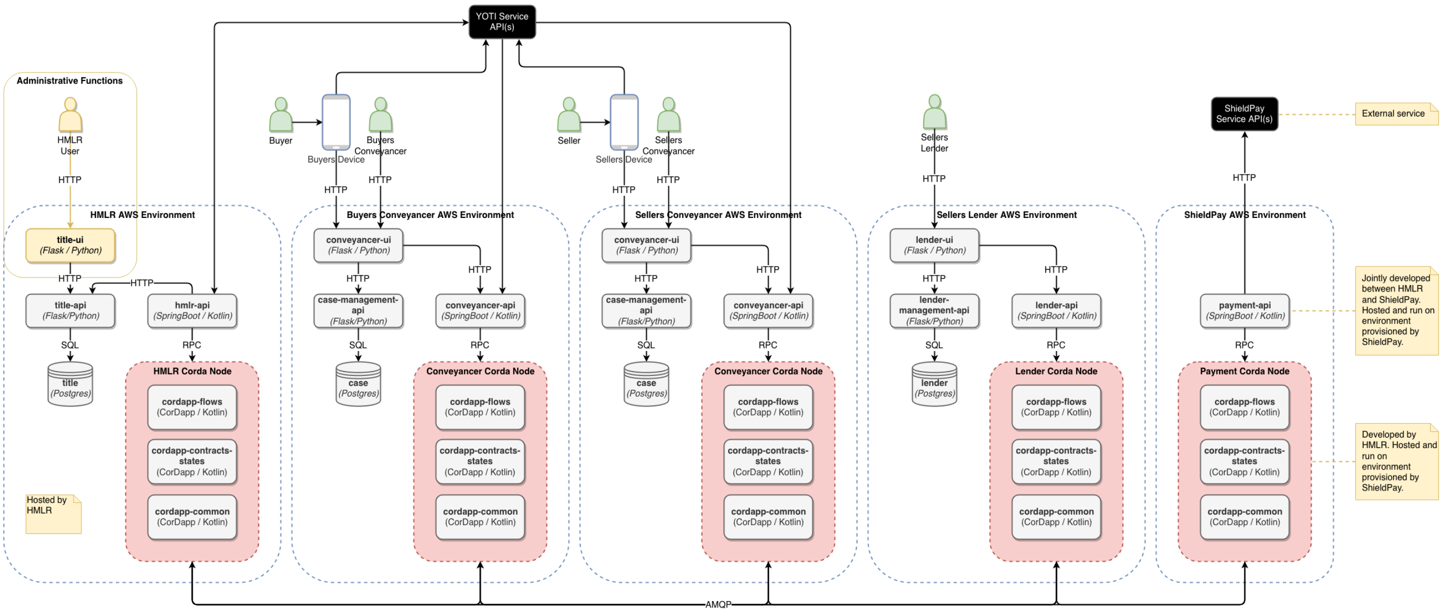

Fig 6 – a simplified CorDapp architecture as used in the Digital Street DLT implementation

We used video conferencing to bring the parties in the transaction together for the final demonstration. The Mishcon de Reya team were based in our Holborn offices in central London. The buyer, Peter, was at work in Medway and his conveyancer was in Manchester. The seller (and our 'client' for the purposes of the conveyance), Stefan, was in his partner's home in Gravesend. The Digital Street team were in Plymouth, with representatives from other consortium members dialling in from as far afield as Malaga, Spain.

Fig 7 – the Digital Street DLT implementation demonstration

The CorDapp enabled real-time sharing of data that was made available to every authorised participant. This made it easier for transaction parties to see what was happening with the conveyance as each step was recorded on the ledger, providing a full immutable and undeniable history to all participants. Transactions were checked by all the participants involved including a notary node, which ensured validity in the exchange and prevented 'double spend'.

4. Key learnings

The Digital Street DLT application was a success and within the controlled prototype evironment provided proof that DLT could enable:

1. speedier conveyances;
2. more trust in the conveyancing process;
3. higher levels of security in the conveyancing process; and
4. increased transparency for all conveyance participants.

In addition to confirming that they believed the project to have been a success, HMLR confirmed that they *"learned a lot of valuable things"* during the project and that they *"found that significant parts of the industry remained open to innovation."* HMLR further acknowledged that they *"cannot fix the problems the industry faces alone, and it therefore needs to be a collaborative effort."*

V. Wider DLT applications in real estate

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The Digital Street implementations relating to the conveyance process represents just one (albeit significant and impactful) possible application of DLT within the real estate sector.

In theory, one DLT system might be implemented to span the entire life-cycle of a real estate asset, from construction through to transacting. In practice however, given the fragmented nature of the real estate sector, it is more likely that several systems will span the life-cycle, each of which will ideally possess a degree of interoperability.

The adoption of DLT systems within the real estate sector will be driven by, amongst other things:

1. **Increasing litigation**
   The real estate sector has become increasingly litigious, as projects and assets involve higher financial stakes and vendors are forced to price their services more competitively.

   In this climate, DLT implementations will become increasingly attractive to stakeholders owing to (i) its potential to improve stakeholders' behaviours by creating a 'Panopticon effect', whereby all stakeholders moderate their behaviours as they know that there is a possibility that their behaviours are (or will be) capable of observation by other stakeholders will access to the shared ledger; and (ii) its immutable characteristics that create and maintain a clear audit trail of actions that will help inform litigation proceedings as they arise.

2. **Internet of Things (IoT)**
   In this paper, when we refer to the IoT, we do so using the broad definition adopted by a May 2015 European Parliament briefing paper entitled The Internet of Things: Opportunities and challenges. That briefing paper defined the IoT as "a distributed network connecting physical objects that are capable of sensing or acting on their environment and able to communicate with each other, other machines or computers." We do not intend this IoT definition to be overly prescriptive or rigid in its application.

   The IoT ecosystem is growing exponentially. Gartner reported that, at the end of 2019, there were 14.2 billion devices connected to the IoT, and predicts that there will 25 billion connected things by 2021. Applied to the real estate sector, the proliferation of low-cost IoT devices may change the way in which real estate assets are monitored and maintained. DLT systems will enable the sharing of data between IoT devices that might be manufactured, installed or maintained by different organisations. This sharing and DLTs immutable characteristics will enable the creation of a real estate asset's "DNA" that persists across its full life-cycle.

This section explores some of the wider applications of DLT systems to the real estate sector. The applications listed are non-exhaustive but indicative of the work we are aware of and involved in across the sector.

1. Construction of real estate

i. Construction supply chains

Existing real estate and construction supply chains often involve many paper-based manual processes. These processes and the siloed manner in which much of the data is stored contribute to an opaque environment in which most stakeholders are often unaware of where their goods are at any given time. This issue is compounded where the goods in question need to be transported in a certain manner and subject to certain conditions, for example timber that should not be exposed to a high level of moisture. At present, it is difficult for stakeholders to verify the proper transport conditions of their goods. The implementation of a DLT system within a supply chain can help to ensure a common shared view of the movement of goods from source to end destination. IoT devices can be used to collect data relating to the transport conditions of goods (e.g. how the long the goods have been stored and in transit, the conditions of storage and transit, and even the route taken in transit). Smart contracts can also be used to automate payments as contracted obligations are fulfilled by various stakeholders along a supply chain. All of this information can be stored in a transparent and auditable manner to identify issues and non-performance within the supply chain, and verify the integrity of goods on delivery and installation.

ii. Building Information Modelling (BIM)

Increasingly, BIM is being used to plan, manage and deliver large construction projects and ultimately assist in the ongoing maintenance of real estate assets. BIM relates to the collection and utilisation of valuable data by stakeholders in a real estate project relating to a wide range of datapoints including component provenance, performance and repair.

Placing BIM data on a DLT system provides greater transparency owing to its immutable and auditable characteristics, a means of deriving insights from data 'owned by' disparate and even adverse stakeholders, and the automation of tasks based on certain data by operation of smart contracts. As with any BIM implementation, IoT devices can automate the collection of data, reducing costs. Currently BIM systems are seldom linked to asset registries and often are siloed away from other property information. A DLT system can help to aggregate this information is a secure, transparent and auditable way.

iii. Title transfer or creation

The linking of pertinent data relating to a real estate asset to its land registry title record is an efficient means of ensuring that such data is made available to a wide range of stakeholders in the asset. This data might include information such as planning, architecture, BIM and supply chain matters that relate to a given real estate asset. This data has traditionally been stored in silos, which can be expensive to access, be difficult to verify, and provide a barrier to cost and time effective price discovery (including necessitating expensive legal due diligence exercises).

The commitment of such information to a DLT system that is maintained by a wide variety of stakeholders can help ensure the integrity of the data, reduce barriers to entry and facilitate more effective due diligence and price discovery exercises. A similar implementation is being developed in Sweden, with a digital blockchain-based solution being developed by Lantmateriet, the Swedish land authority.

2. Buying and selling real estate

i. Property search

The most common method of searching for available real estate is through searching for property listings either held by brokers (i.e. estate agents) or placed on property portals (e.g. Rightmove, Zoopla, etc.). The information held by these agents and placed on these portals is frequently inaccurate, lacking in standardisation, and stored in (often manual, offline) silos. Furthermore, data about real estate is often fragmented across platforms and may be difficult (and expensive) to uncover its entirety.

Once again, a DLT can aggregate such information in a secure and transparent way, link real estate data to the relevant title number(s) to ensure the integrity of the data, and achieve efficiencies in the information (and consequent price) discovery processes. Such an implementation would reduce the transaction costs and therefore the friction that is associated with the transaction of real estate assets.

ii. Real estate investing and tokenisation

Absent highly regulated investing mechanisms such as real estate funds or real estate investment trusts, investing in real estate has involved the acquisition of a non-fungible asset class. This has traditionally required a lump sum of capital (e.g. a deposit) and a loan (e.g. a mortgage) to acquire the real estate asset. This has created a barrier to entry for those seeking to invest in real estate assets and the process involves a number of intermediaries with associated costs. Investing in international real estate assets is more complex still.

A number of projects are developing DLT systems that enable tokenised investing into fungible assets connected to real estate, including notably a collaboration between HMLR and Consensys Codefi. A DLT-based real estate tokenisation or digital twin mechanism would enable the partial ownership of the legal, beneficial and/or economic interests in a real estate asset, which might be registered, and transfers recorded on, a transparent, verifiable registry. DLT enables an efficient mechanism to facilitate the transfer and clearing of real estate assets in this respect. Smart contracts can also facilitate automatic payments and provide voting functionality for decisions that are required to be made by interested stakeholders (i.e. token holders), for example relating to maintenance, letting decisions or investment.

Tokenisation implementations require careful legal and regulatory input given the regulated nature of real estate as an asset class but, given the value of real estate as an asset class – the real estate recorded by HMLR is valued at over £7 trillion in the UK alone –the incentives are significant for those innovators who can navigate the legal and regulatory landscape and deliver a compliant solution. A significant body of academic research has explored this area, including notably the University of Oxford's Saïd Business School's recent report entitled *Tokenisation: the future of real estate investment?.*

3. Ongoing management of real estate

i. Financing and payment mechanisms

The processes involved in financing and the making of payments in relation to real estate assets suffer from the same issues of opaqueness, siloed information and poor-quality data already discussed in detail in this Section. These factors result in inefficient and ineffective price discovery and represent a transaction costs that deter market activity.

As well as DLT systems providing transparency and aggregated datasets for interested parties, smart contracts can automate many of the processes. For example, smart contracts might be used to automate funds flow on confirmation by the relevant parties that they have completed and satisfied their respective due diligence, financial evaluation, and verification of ownership exercises. Similarly, a DLT system can automate lease and tenant rental payments, on satisfaction of reputational and credit rating checks (each of which can also be integrated into a DLT system to improve transparency and verifiability). A number of well-documented DLT-based projects are also seeking to facilitate quicker, cheaper cross-border payments using cryptoassets.

ii. Maintenance

The maintenance of real estate assets is an expensive exercise and can often involve manual checking processes and guess-work in determining the priority of component repairs and replacement. The BIM systems discussed in this section can be continued and applied after the construction of a real estate asset and be used to better manage that real estate asset's maintenance. For example, by aggregating and sharing datapoints derived from IoT devices, a DLT system might monitor in real-time the degradation of certain components of a real estate asset and according prioritise their replacement or repair accordingly, rather than on a rolling-basis accordingly solely to time elapsed.

iii. Environmental

The carbon footprint of real estate assets is an important consideration that will only become more essential for investors, owners and asset managers to consider as the climate crisis becomes more pressing and heavily regulated. It is currently extremely difficult for estate managers to meaningfully calculate, demonstrate, and therefore offset their real estate assets' carbon footprints.

A DLT system might be used to record carbon emissions and offsets and link them to real estate titles, providing an immutable and auditable history of a real estate asset's carbon footprint, and enable stakeholders to stake steps to improve the asset's position. DLT would provide much needed transparency and trust to an area that has high incidences of inaccuracy, misreporting and fraud.

VI. Challenges to real estate adoption of DLT

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The exercise of mapping prevailing practical, legal and regulatory steps onto technical architecture is a specialised activity that the Mishcon de Reya team are well placed to carry out. More broadly however, DLT still faces several barriers to mainstream adoption in the real estate industry. This section provides a very high-level overview of such barriers categorised in three distinct themes: awareness; technical; and legal and regulatory.

1. Awareness

A lack of awareness of DLT and understanding of DLT systems is one of the principle barriers to its widespread adoption. Notably, the conflation of DLT with cryptocurrencies, in particular following the so-called 'ICO boom' of late-2017 that saw a significant number of fraudulent and/or misleading claims made regarding the potential functionality and value of various cryptoassets, has had a chilling effect on DLT adoption.

Awareness of DLT is improving, however. A recent report from Deloitte includes survey data indicating that 55% of organisations consider DLT-based implementations to be a 'top 5' priority for them in the next two years, with 88% of respondents considering that *"[DLT] is broadly scalable and will eventually achieve mainstream adoption."* This bodes extremely well for the real estate sector and leaders are advised to carefully consider the use-cases and applications that will be most pertinent, impactful and disruptive to their respective businesses.

2. Technical

DLT remains a relatively nascent, immature technology. This is perhaps most keenly demonstrated by: (1) its ability to perform at scale; and (2) its interoperability, both between DLT systems and with other technologies.

Many existing DLT systems struggle to perform at scale, with well-distributed systems often suffering with high latency and low throughput. The Bitcoin blockchain for example only capable of processing up to seven transactions per second which, clearly, is suboptimal for any use-case requiring fast transaction speeds (though it must be said that such clearing times would still represent a significant improvement on current conveyance processes). This is improving, however. The Corda platform that was used for the Digital Street application is at the time of writing capable of processing 170 transactions per second, and this figure (and the equivalent figure across a number of other DLT platforms) is being improved regularly. Broadly speaking, private DLT systems with less distributed networks perform markedly better than public DLT systems, including DLT systems other than blockchain such as directed acyclic graphs.

The absence of established standards and the resultant lack of interoperability of DLT systems has also inhibited their widespread adoption. Historically, the disparate forms of DLT, spanning a variety of data structures, coding languages, protocols, cyber security features and consensus mechanisms, has made it difficult for actors to collaborate and has risked the creation of a fragmented DLT ecosystem. This too is changing. The integration of 'enterprise-ready' DLT systems with well-established cloud computing offerings is increasingly possible, while the emergence of abstraction-layer DLT system offers an alternative way to aggregate and share previously siloed DLT-base datasets. This has been a positive development for DLT systems and looks set to continue.

3. Legal and regulatory

A recent PwC report identified regulatory uncertainty as the single biggest barrier to DLT adoption for its respondents. This is unsurprising – DLT systems raise a number of legal and regulatory questions, from data protection and system governance rules, through to tax and property law. This is particularly relevant in the real estate sector, which is highly regulated.

The last two years has seen the English legal system take significant strides to provide certainty to DLT. Though there are no DLT-specific legislative or regulatory frameworks in the UK, recent developments have made it clear that many applications of DLT fall within existing legal and regulatory perimeters. For example, the fifth Money Laundering Directive as implemented in the UK makes explicit reference to DLT in the context of cryptoassets and, amongst other things, brings providers of custodian wallet services and virtual currency exchanges within the scope of anti-money laundering (**AML**) regulations.

The relevant authorities published a number of DLT-related guidance pieces in 2019, enhancing legal certainty in the UK. For example, in July 2019, the Financial Conduct Authority (**FCA**), following consultation, published guidance in a Policy Statement (FCA Policy Statement 19/22) for market participants wishing to understand whether their activities might fall within the FCA's regulatory perimeter. This was followed in November by a statement by the UK Jurisdiction Taskforce (**UKJT**) regarding legal questions as regards the status of cryptoassets and smart contracts. In December 2019, the UKJT's statement was referenced and endorsed by the High Court of England and Wales in *AA* v *Persons Unknown*. In addition, the UK tax authority, HMRC, continued to update its guidance on the taxation of cryptoassets in the UK.

Further legal clarity is expected to be provided regarding DLT in 2020 and beyond. The FCA is consulting on whether to prohibit the sale, marketing and distribution of derivatives (i.e. contracts for difference, futures and options) and exchange traded notes that reference certain cryptoassets. Its final policy statement and Handbook rules are expected in Q2 2020, though may be delayed by the COVID-19 pandemic. In addition, HM Treasury is consulting on legislation that would seek to expand its regulatory authority to include cryptoassets, with a view to bringing further cryptoasset service providers with the scope of the UK's AML and counter-terrorist financing regimes. The FCA and the Prudential Regulatory Authority are expected to review their own positions following the release of HM Treasury's findings. There are also various other legal and regulatory issues that we expect to face blockchain platforms in the coming years, including in respect of competition law. Finally, the Legal & Regulatory sub-working group of Tech London Advocate's Blockchain Working Group, in partnership with the Law Society of England & Wales, is due to release guidance for legal practitioners working on transactions involving smart legal contracts in Q3 2020.

These developments continue to pave the way for the UK to embrace DLT and mean that would-be adopters of DLT in the real estate sector can benefit from greater legal and regulatory clarity than ever before.

VII. Contributing organisations

This project has been made possible by contributions from the following organisations:

HM Land Registry safeguards land and property ownership worth in excess of £4 trillion, including around £1 trillion of mortgages. The Land Register contains more than 25 million titles showing evidence of ownership for more than 85% of the land mass of England and Wales.

HM Land Registry's mission is to guarantee and protect property rights in England and Wales. HM Land Registry is a government department created in 1862. It operates as an executive agency and a trading fund and its running costs are covered by the fees paid by the users of its services. Its ambition is to become the world's leading land registry for speed, simplicity and an open approach to data.

HM Land Registry's ambition is to be at the forefront of innovation by exploring how land registration and conveyancing can be made easier and how technology and data could revolutionise the process.

Digital Street is just one of many projects being developed by HM Land Registry as part of the organisation's Business Strategy. The organisation is exploring a number of potential services to make the buying, renting, selling, financing, building and managing property easier.

Methods is the leading digital transformation partner for the UK public sector. They bring innovation, bespoke development, and service management capability to align UK public services around citizens and safeguard them for future generations.

Methods was selected following a tender process which attracted 22 bids to support the Digital Street project team and develop greater in-house expertise.

Mishcon de Reya is based in London with offices in Singapore, and services an international community of clients and provides advice in situations where the constraints of geography often do not apply. The work they undertake is cross-border, multi-jurisdictional and complex.

The Mishcon de Reya Group comprises standalone businesses MDR Brand Management, MDR Cyber and MDR Discover, and included both legal and technical expertise to ensure our clients' systems are compliant by design. Complementary to their core areas of work, each group company is led by best in class professionals recruited from a variety of non-legal industries and sectors.

R3 is an enterprise blockchain software firm working with a broad ecosystem of more than 200 members and partners across multiple industries from both the private and public sectors to develop on Corda, its open-source blockchain platform, and Corda Enterprise, a commercial version of Corda for enterprise usage.

R3's global team of over 180 professionals in 13 countries is supported by over 2,000 technology, financial, and legal experts drawn from its global member base. R3 is backed by investment of over $120 million from more than 45 firms. The Corda platform is already being used in industries from financial services to healthcare, shipping, insurance and more. It records, manages and executes institutions' financial agreements in perfect synchrony with their peers, creating a world of frictionless commerce.

Blockchain Digital is a leading business process innovation and service design consultancy, focused on the application of blockchain in the public sector and enterprise.

My Home Move Conveyancing is a trading style of Premier Property Lawyers Limited. Premier Property Lawyers Limited is the largest residential conveyancing law firm in the UK and employs over 300 conveyancers. It currently has 38 Licenced Conveyancers, 70 Solicitors and 13 Legal Executives.

Persistent Systems, a $470 million listed company, builds software that drives the business of their customers; enterprises and software product companies with software at the core of their digital transformation.

Shield Pay's mission is to eliminate not just peer-to-peer fraud but all payment fraud so that everyone, everywhere, can transact with each other with total confidence. Fully authorised and regulated by the FCA for payment services, they protect both buyer and seller in any transaction by verifying the identity of both sides. Funds are held securely in the Shieldpay vault and are only released when both parties agree. Shield Pay have partnered with Visa to revolutionise digital peer-to-peer marketplaces by enabling the secure use of payment cards on marketplaces and classified sites, globally.

Yoti is a London-based technology company on a mission to become the world's trusted identity platform. Founded in 2014, it has a team of over 200 people with headquarters in central London, an office in India and a growing presence in the USA.

Thanks also to John Abbott (now Head of Digital, Saudi Arabian Public Investment Fund), Lauren Tombs (now Transformation Manager, Methods) and John Reynolds (now Chief Operating Officer, Coadjute) for their valuable contributions to the project.

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