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Blockchain - feasibility and opportunity assessment

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Foreword

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There has been much media attention in recent months on Bitcoin and the blockchain technology that underpins it. At BRE we have sought to shed some light on this evolving technology and what value it could bring to the built environment.

Blockchain and Distributed Ledger Technology is very much en vogue at the moment. There are still many questions that are being asked in respect of this technology from 'how much energy does it consume to mine the blocks' to 'what extent will it fundamentally change the way we live and work'.

The BRE Trust has kindly supported this feasibility paper which makes no apologies for presenting a series of further areas of research and validation of these technologies. To this end we convened two workshops with a wide range of interested parties to initially draw out the areas of consideration and application and then to further validate these in the second workshop. This report summarises the discussion and evolution of thought over these two sessions. Our thanks go to all of our participants and Constructing Excellence.

The areas developed for further consideration presented in this report are:

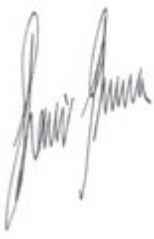
1. Digital passports
2. Smart contracts
3. Resourcing
4. Connected systems

Clearly these areas overlap but we found ourselves coming back to the principle that blockchain technologies may not necessarily offer new methods but can enhance and add rigour or efficiency to systems that, in some cases, are challenging and create problems in project management and delivery.

There are technical obstacles to overcome and the realisation that blockchains can be private as well as public, some with devolved functions and others that can be directly controlled is worthy of further thought.

As with many ideas and possibilities in business there needs to be clear return and value creation; whether this is social, environmental, and economic or mitigates risk in another sphere and protects/enhances the reputation of the company. Distributed ledger technologies can create this value and return but we need to be very considered in the selection of the process in which this heralded technology can be deployed effectively.

BRE welcomes all interested parties to get in touch and join the debate to facilitate a considered and expeditious route to harnessing the benefits of the next technical revolution.



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Introduction

Blockchain and Distributed Ledgers

Technological advances, in both materials and computer sciences, are providing the greatest source of innovation within the built environment. These innovations are allowing us to design and create, more efficient, intelligent and safer buildings, however, the increasing globalisation and interconnectedness of the built environment is highlighting new challenges; from modern slavery, to counterfeit materials and certifications, there is an increasing effort to focus new technological advances at addressing these new challenges.

One of these innovations, distributed ledger technologies (DLTs), are unique. While the principle use of DLTs is as a means for creating more reliable, trusted and shared data sources (as explained further below), their scope of application and potential value, within and outside of the built environment sector, is still being defined.

Currently, many data driven applications and sectors are based around a centralised system; a single point of information capture, storage and analysis. In contrast to this, DLTs use a network of connected 'nodes', distributed across various geographies, institutions and countries, that each hold the same record of transactions within a specific database; otherwise referred to as a ledger. Any transaction of value, whether that be information, monetary etc., is verified by consensus and recorded chronologically using their cryptographic number by each and every node within that DLT. In doing so, a trusted transparent record of actions is created.

The concept alone is hugely disruptive by definition. By removing, or at least limiting, the requirement of intermediaries for transactions and allowing a widely distributed real-time means of sharing information the potential for innovation around current processes is amplified.

Further to this, there is a particular type of DLT known as blockchain. Blockchains package together a number of unique transactions, identified by their unique cryptographic number, into a 'block'. These blocks are then chained to the previous block in the sequence using a cryptographic signature, known as a 'hash'. In this way, a blockchain can be used in the exact same way as a distributed ledger, however it also allows for other elements to be included in the application. For example, the creation of blocks acts as a 'proof-of-work' involving the use of computer power to solve algorithms and successfully create a block. This prevents fraudulent addition to the blockchain as it increases the necessary computational and electrical power required to alter blocks (and any superseding it) and hold more than the 51% of nodes required to do this[1]. Proof of work is then rewarded with 'tokens', which can be anything, from representing specific assets, to a means of tracking things through the blockchain through various transactions.

In addition, this form of DLT allows for rules to be determined for a transaction as code can be added into the blockchain. Code can determine conditions for data to be added to the chain, creating a self-automated process.

In its basic form blockchains and DLTs provide an evident means for creating an auditable trail of transactions, however the scope goes far beyond the recording of peer-to-peer trading. Being a trustless, unchangeable, decentralised record gives potential for the technology to address many issues currently apparent within societal, environmental and economic spheres.

Therein sits the purpose of this research; to determine this potential within the built environment, providing an overview of where and how this technology could provide the innovation needed to create solutions and further current programmes and applications.

Assessing Built Environment Application

Industry is starting to investigate the potential applications for blockchain and DLTs within the built environment sector; UCL has recently initiated a Centre for Blockchain Technologies[2], while other research lead foundations and governmental bodies such as Lloyd's Register Foundation and the Government Office for Science[3], have released reports outlining the potential impact of these technologies[4]. This is still, however, early days in understanding the scope for this technology group, with a small selection of individuals within our industry leading on this.

BRE holds a unique position within the industry as an independent trusted body for research, certification and advisory services. This presents us with a special platform for guiding industry in understanding and applying this technology.

As with any disruptive new innovation there is a need to fully understand how it functions and how it could be used within the industry before more concentrated efforts of research and demonstration. BRE, funded by the BRE Trust, and supported by Constructing Excellence, undertook this piece of research, engaging with key stakeholders in the built environment, in order to prepare a landscape review of the potential opportunities and risks associated with blockchain and DLTs in order to better inform future work.

The following report presents the outcomes from two workshops facilitated through the Constructing Excellence network, engaging with interested parties from across the sector. The focus of each workshop is as follows:

Workshop 1 (22.09.2017) – Understanding how blockchain and DLT could be applied, the potential benefits and problems with application, and what specific sector areas these technologies would apply to.

1 By holding more than 51% of the distributed nodes an individual party would be able to dominate the blockchain/DLT, therefore undermining the aspect of a 'trustless system' that is not governed by a single dominating power. This is nearly impossible to achieve due to the design of blockchain specifically to address this through proof-of-work.

2 http://blockchain.cs.ucl.ac.uk/

3 https://www.gov.uk/government/publications/distributed-ledger-technology-blackett-review

4 http://www.lrfoundation.org.uk/publications/download-insight-report-on-distributed-ledger-technologies.aspx

Workshop 2 (09.11.2017) – Investigating specific sector applications and wider issues related to blockchain and DLT application.

Common themes were evident throughout the workshops, with the necessary next steps being both clear yet potentially large in scope. Each workshop is detailed herein with the combined findings and future actions outlined in the summarising chapter.

Definitions

Below is a list of terminology used within this report. To ensure understanding of intended meaning, in particular where terms are used in other areas of the built environment industry, all technical terminology has been defined.

Block – the key difference between a DLT and a blockchain is the block. These chronological blocks contain information regarding transactions as well as a timestamp, the previous blocks hash, and information about the algorithm required to mine the block.

Blockchain – a form of distributed ledger technology that consolidates numerous transactions, as identified by their cryptographic number, in a block, that is then added to the chronological chain of blocks via a hash on the distributed ledger through the mining process.

Distributed Ledger – a chronological, transparent, digital record of transactions and information that, instead of being held in a centralised database, is distributed across a diverse network of nodes.

Hash – a hash is the output of a one-way hash function that packages inputs into an output of a specific size and format. This process ensures information is translated into a manageable size that also prevents the input information from being seen; further establishing the trustless element of DLTs and blockchains.

Mining – this is the term given to the computational effort required to solve an algorithm, creating the next block to be added to the chain.

Node – the distributed system is made up of nodes that each independently validate transactions on the blockchain.

Private Blockchain/DLT – permissions are controlled by a trusted organisation. This organisation can control whether users can or cannot have various levels of access to the information, who can add to it and what transactions are permitted. This allows for a far quicker system that is reliant on trust.

Private Consortium Blockchain/DLT – a type of private blockchain that allows a number of predetermined nodes to participate in the verification and transaction process. This is a hybrid between private and public blockchain, creating a partially decentralised blockchain.

Proof of work – the proof of work concept both deters cyber-attack and creates value. This is achieved through the need for nodes to define an expensive computational problem; a process called mining. This process requires computational power, which translates into energy. In rewarding the node/miner that computes this the fastest, value is created.

Proof of stake – in contrast to proof of work the creator of new blocks is not determined through mining, rather the creator is determined based on 'wealth', or stake. There is no reward (as all coins/tokens are created from the outset), and a computational problem is still required to be solved, however transaction fees are required, providing incentive.

Public Blockchain/DLT – a decentralised blockchain that can be added to and read by anyone. Permissions are shared equally by all users of the network, creating a completely trustless system.

Tokens – the representation of the tradable 'goods' being used within that blockchain. This includes, but is not exclusive to, currency, information, points, certificates etc.

Trustless – in removing the requirement for a 'trusted' third party (a single centralised control that oversees transactions between peers), blockchains are able to create a decentralised system that does not require trust. Instead, self-executing peer-to-peer transactions are carried out that are recorded and verified by the whole system, therefore removing the need for one trusted body.

Workshop 1 – Understanding blockchain within the built environment

The purpose of this first workshop, that took place on the 22 September 2017, was to investigate the general first reactions to blockchain technologies among those in the industry with a level of understanding for its application. The workshop was split into two main discussion areas:

1. Understanding how blockchain could be applied in a general scope and what the potential benefits and problems could be.
2. With specificity to the built environment, what would the uses for blockchain technology and what would the implications be.

In attendance were:
Shamir Ghumra, BRE
Stuart Chalmers, BRE
Colm Quinn, BRE
Harriet Cooper, BRE
Peter Hill, Causeway
Ian Stanton, S:unblock (previously Epi Consulting)
Alex Giles, Action Sustainability
Ben Pritchard, Invent Consultancy
Dave Knight, One Planet
Adrian Henriques, Independent Sustainability and CSR Advisor

Blockchain applications and potential benefits and problems

Early discussion focused on distinguishing between those using blockchain as a tool and those using it to make money; namely, those who act as 'nodes' on the chain and 'mine' it. These miners effectively provide the computational power to wrap-up each block (by solving algorithms) and also act as one of the many decentralised records of that specific blockchain. They do this for value gain based on effort rather than an interest in that blockchains use. In contrast, other users of a chain use it for its purpose as a distributed ledger of things.

During the most part of this session discussion focused on numerous topics that can be best summarised in the table below. It should be noted that this table is by no means complete or representative of the knowledge attendees have on this topic area, rather it contains the points raised during this workshop.

TOPIC	BENEFITS	DISADVANTAGES
Mining of the blocks	• A means for generating value/income at minimal human effort. • This incentive encourages miners and therefore more nodes; a vital element to blockchain security.	• Mining requires a high energy usage. At a personal level this drives up bills, while at a more general level this higher energy usage could be an important consideration for sustainability sectors; the overall gain from the blockchain product would need to negate this.
Audit transparency and validation	• Reduces the burden of the centralised system.	• Is validation self-proclaimed, or would a third party have to assure it? This is an important point as one of blockchains selling points is that it is a 'trust-less' system that would remove the need for third parties.
Guaranteed trust	• You can encode the chain with all sorts of information that it has to verify; therefore, a high level of detail can prevent false entries into the chain. This higher level of detail tends to have additional benefits.	• Blockchains main advantage is the fact that is cannot be altered, therefore guaranteeing trust. However, if the input is itself a lie, you are trusting lies. There is a need to remember the people and process element of it – blockchain does not answer this (although it doesn't profess to, it just aims to be un-hackable). • There needs to be a process for guaranteeing truth in the input.
Commercial perspective	• Offers an improved way of peer-to-peer payment across borders.	• Variation of contracts has a potential increase in legal costs.

TOPIC	BENEFITS	DISADVANTAGES
Time	• Removes the effort required to look through the records and verify them as they are all in one system.	• The processing of transactions and adding of blocks to the chain is dependent on how many nodes there are. This is a limiting factor in the computational speed of a blockchain based application.
Uptake	• The inherent nature of blockchain should lend it to being a trusted technology. • Do we often have to understand things to trust them? We use many technologies that as individual consumers we do not fully understand.	• Businesses and consumers may be wary of using a tool they do not full understand. • How, and do we, need to convince customers they need blockchain?
Ownership of data	• Could help the General Data Protection Regulations carry into force in May 2018.	• In relation to commercial use there would need to be clarification on who owns the data. The creator of the blockchain? Those using it and adding in the data? The miners? Or is it a collective?
Transparency	• Blockchain would allow companies to be more transparent with their records of internal operation and transactions as the blockchain is un-hackable, therefore removing the risk of making records public.	• Some sectors in the built environment are very sensitive about data i.e. suppliers and materials.
Smart contracts	• Ties in with elements of commercial benefits and trust – blockchain based contracts would be coded as such to ensure that only what is allowed/acceptable will be accepted and therefore contribute to the blockchain and release an exchange of elements of value (money, goods, knowledge etc).	• Requires contracts and legal thoughts to occur earlier in the project.

Applying blockchain technology to the built environment

It is evident that potential application of blockchain in the built environment sectors is wide and varied. With a lot of these applications the discussion is not about 'what do we need blockchain for', rather the focus is on 'how can blockchain improve this'.

The nature of the technology does not immediately present any new means for improving sustainability and responsibility in the built environment. Instead, it provides an opportunity to do things better. A summary of the different application areas and the potential benefits and disadvantages of using blockchain are summarised in the table below.

Again, it should be noted that this table is by no means complete or representative of the knowledge attendees have on this topic area, rather it contains the points raised during this workshop.

TOPIC	BENEFITS	DISADVANTAGES
Commercial	• Built environment sector is notorious for poor payment, blockchain could help negate this by providing an automated platform for easy payment.	• Would require large uptake across the sector.
Digital Passport (BIM, BAMB & Digital passports)	• Circular economy traceability • Material/building passports would allow for understanding of exactly where a material came from, who supplied it, and who installed it (ties in with BAMB project). • In terms of decommissioning and end of life, blockchain would provide a valuable information source.	• BIM already provides a lot of these mentioned benefits. However, BIM Level 3 could not work without something new, blockchain could be this.
Smart Contracts	• Blockchain could ensure the proper delivery of tasks as criteria can be coded into the chain that prevents the addition of information/exchanges if these are not properly met.	• You cannot change a coded required/contract as it is locked into the blockchain, however, you can cancel it and replace it with a new one.
Planning	• Often time is wasted verifying things multiple times by different bodies. As a trusted source that can employ criteria for addition of data, blockchain can provide a solution – a trusted single source of verification.	
Digital Twin	• By creating a digital twin of a building, community or even city it would be possible to better hypothesise developments through understanding what is already there (transport, services, implications). • A digital twin would save time, allowing for more considered planning and design and better environmental management. • Blockchain verified data could add value to property as buyers would be happy to pay more knowing they would get all this verified information that is otherwise hard to get hold of. • For infrastructure such as nuclear reactors a trusted digital twin would be incredibly useful during decommissioning.	• Currently there is value in lack of transparency of building information, might not be able to get this digital twin (instead the value would come from adding quality to this information)

TOPIC	BENEFITS	DISADVANTAGES
Building Regulations	• Ability to prove you have built a building to the necessary standards and passed the tests/surveys needed.	• Hugely complex area and one that might fundamentally change post-Grenfell.
Labour and Skills	• Could be used to address the issue of responsible working and modern slavery in the built environment sector (verification of labour providers). • At an individual level you could create a digital identity verification.	• Privacy implications (would need to be private data).
Internet of Things	• Increased speed of transactions • Would help with the security aspect – concern that increased connectedness of the built environment would enable easier access of malware etc. Blockchain could address this.	• Complexity of interactions/nodes.

Importantly, with all of these applications there is still a need for certification and verification by a independent body. There is a huge scope for business around validating who is on the chain (identify) and adding information. In addition, businesses with prove responsibility may be crucial for wider uptake of blockchain based applications.

Key Themes

Following the two discussion areas concluding remarks were made that captured the main implications and potentials for blockchain/DLT technology that became apparent through the workshop. These can be summarised into the following areas:

a. Need

Do we really need blockchain if we are doing all of these things already – blockchain isn't opening up new commercial areas, it is just bettering what we are already doing. We need to understand fully how exactly blockchain will better each of these areas.

b. Cost

The cost of using blockchain would be high, especially at the beginning. A lot of data would require a lot of capital. For example, Ethereum is charging a lease for its open source blockchain, and there is a cost for every transaction made (needed for validation and creation of the block). This cost could be from running your own private nodes (both in cost and energy although these would have to be across numerous geographical areas) or financial costs to facilitate the transactions.

c. Governance and legality

Governance is important, both for contributing to trust and for the legal implications. We need to understand how there can be more assurance for countering human error in blockchain; trust and boundaries are key for uptake and this needs to be fully investigated. There is also a need to better understand what legal implications there are for blockchain (particularly with smart contracts).

d. Holistic view

With all of the suggested applications there is a need to look at the 'bigger picture'. In particular we need to understand whether blockchain is helping or hindering aspects such as decarbonisation, energy usage etc. and what cultural and societal issues blockchain would address/create.

Workshop 2 – Investigating sector applications of blockchain technology

Following on from the initial ideas-sharing workshop on 22 September, a more focused investigation into the application of blockchain/DLTs in various sectors of the built environment was conducted through a second workshop, held on 8 November 2017.

Specific sectors were chosen based on the previous workshop discussion and expanded on, providing a basis for more detailed examination of the barriers and opportunities of application within a more defined scenario. The sectors investigated included:

1. Digital passports
2. Smart contracts
3. Resourcing
4. Connected systems

In attendance were:
Shamir Ghumra, BRE
Stuart Chalmers, BRE
Cathy Crawley, BRE
Colm Quinn, BRE
Harriet Cooper, BRE
Ian Stanton, S:unblock (previously Epi Consulting)
Ben Pritchard, Invennt Consultancy
Adrian Henriques, Independent Sustainability and CSR Advisor
Rajvant Nijjhar, iVEES
Jacqui Glass, Loughborough University
Cathy Berry, Action Sustainability / Supply Chain Sustainability School
Alex Small, Tata Steel
Sree Vinayak, Invennt Consultancy

Each sector area is outlined below to show the potential scope of a blockchain/DLT application as well as the contributing content generated during this workshop. Throughout, discussions around barriers and next steps were had, showing clear themes of implementation across all industry applications. These common themes and concepts for further work are outlined after the sector application scopes, with further detail being given in the following chapters: Summary of Findings and Further Research Themes.

Digital Passports

Material lifecycles & Asset certification

This sector application is unique in that it includes two elements; the digital passport for the physical materials used, and the digital passport for the certifications and qualifications of the building and stakeholders involved in its design, construction and maintenance.

Digital Passport - Material Lifecycle Attributes

Creating a single source for all information regarding materials-level attributes throughout their lifecycle. E.g. chemical make-up, manufacture, maintenance etc.

What would this look like?

A ledger of a materials physical attributes (including components of products) from sourcing and manufacture to maintenance and waste processing; providing a trusted record of information. This would improve material knowledge and accountability enabling growth in circular economy and attribution of fault.

Looking at contributing to the next steps of projects such as BAMB (Buildings as Material Banks).

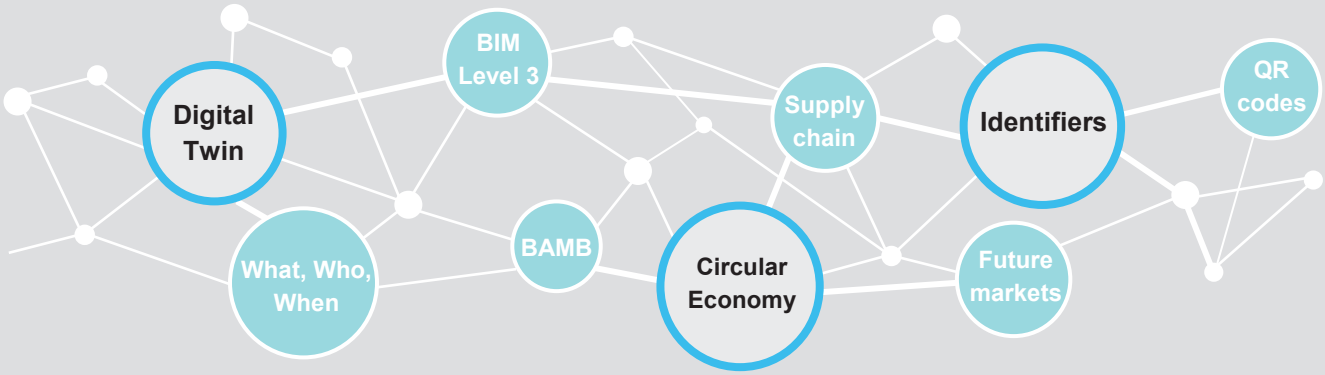
Digital Passport - Asset Certification

Establishing a trustworthy location for all information regarding material to building level certification.

What would this look like?

Material- through to building-level certifications stored in one trustworthy ledger that would enable a reliable means of verifying assets. This would provide information on what certification was achieved, to what level, assessed by who and when, and what updates have been made to these certifications.

Looking at contributing to the next steps of tools such as BIM.



Benefits

- Lifecycle traceability in one location (inc. performance and maintenance data)
- Combines certification and verification elements of buildings and stakeholders with physical and chemical information on materials
- Driver for better circular economy behaviours
- Provides accountability for material content and installation
- Bridges collaboration between professionals and clients through platform or proven trust
- Speed up centralised system of verification

Problems

- Need to better understand what this technology could add to existing tools such as BIM; just because its available doesn't mean it has to be used
- Potentially too disruptive in an industry that historically doesn't deal well with change
- With this, the greatest level of work needed to implement goes against the driven value in the supply chain

Smart Contracts

Self-executing coded contracts

Blockchain and DLTs provide an opportunity for self-executing contracts due to the ability to code in clauses based on an agreement between peers; whether that be a buyer and seller of services or a product.

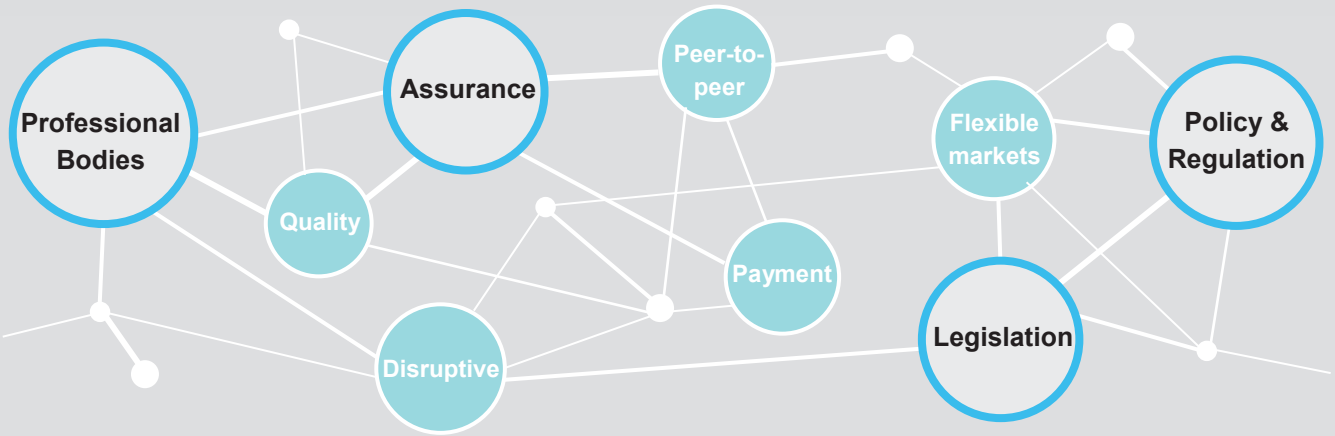
Smart Contracts

DLTs have been widely discussed as a means for Smart Contracts. In this application DLTs would act as a means for automating exchanges and ensuring conditions are met – 'if/then' principle.

What would this look like?

A platform that would allow an unambiguous contractual relationship between service providers and those buying that service. Automated contracts would address an industry problem with delays in payment and service provision. This could also act to change the current set-up where there are many middle men between client and end product.

This application often forms part of a blockchain/DLT use and would likely be used in many of the developed sector area DLTs discussed.



Benefits

- Accountability through digital audit trail
- Ease of administration and lowered costs of transactions and administration
- Improve trust in the construction industry. Payments are received within better time frames and there is an assurance of quality work

Problems

- Uncertainty as to where the liability would be for errors in the written code
- Uptake by industry is not guaranteed. There could be a nervousness around intelligent contracts, while success is largely rooted in a supply-chain wide uptake
- The human element of creating contracts and relationships is important to many; this would remove that.

Smart contracts would reduce the scope for human error with regards to transactions, however…
… written code is only as good as who wrote it. The element of human error is not entirely removed

Resourcing

Labour and skills

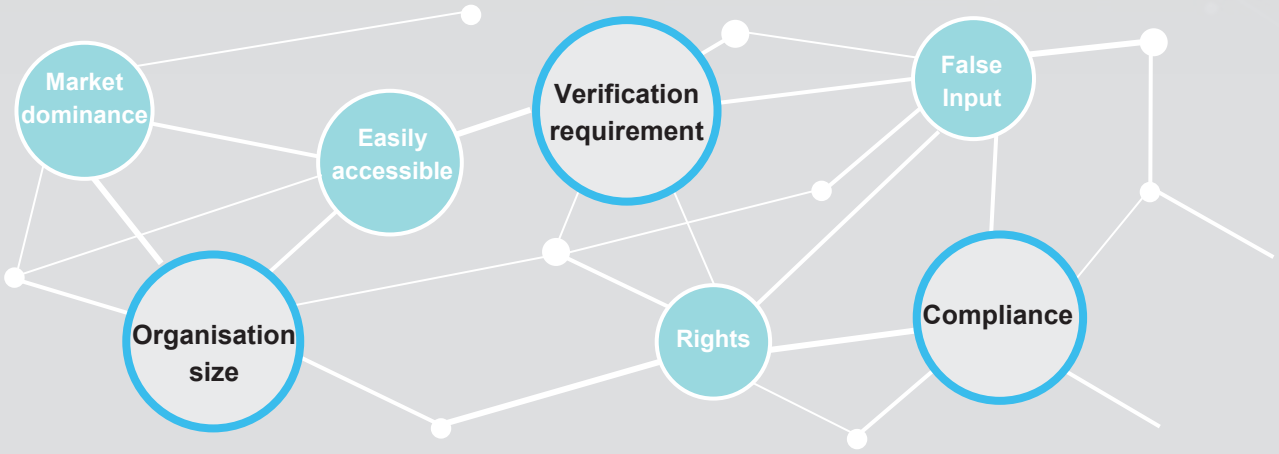
Resourcing and skilled labour is a growing issue within the industry. Assurances surrounding qualified work people and the continuing issues of modern slavery are creating a huge requirement for the reliable resourcing of labour.

Resourcing

Reliable assurances of responsible labour and skills sourcing is a key requirement in the industry. This covers issues such as modern slavery, corporate responsibilities and legitimate skills assurances.

What would this look like?

Blockchain and DLTs can provide digital identities to those without (and with) passports, as well as provide a trusted, transparent ledger of accountability. These two things could act within a platform to ensure sourced labour is responsible and fair. A workers contribution and the organisational hierarchy can be stored to ensure an accountable system of sourcing.



Benefits

- Would directly benefit the most vulnerable, such as those without passports or any other recorded identity
- A single source record of skills and qualifications in addition to potential aspects of reviewing/rating of workers and their work

Problems

- Still requires a third party to verify identities and skills, while this may add assurance, it also gives scope for false input
- The issue of trafficking goes beyond personal identities
- Would need to ensure compliance with the 'right to be forgotten'. Blockchain, by nature, does not forget, but information could be blocked

Connected Systems

Internet of Things

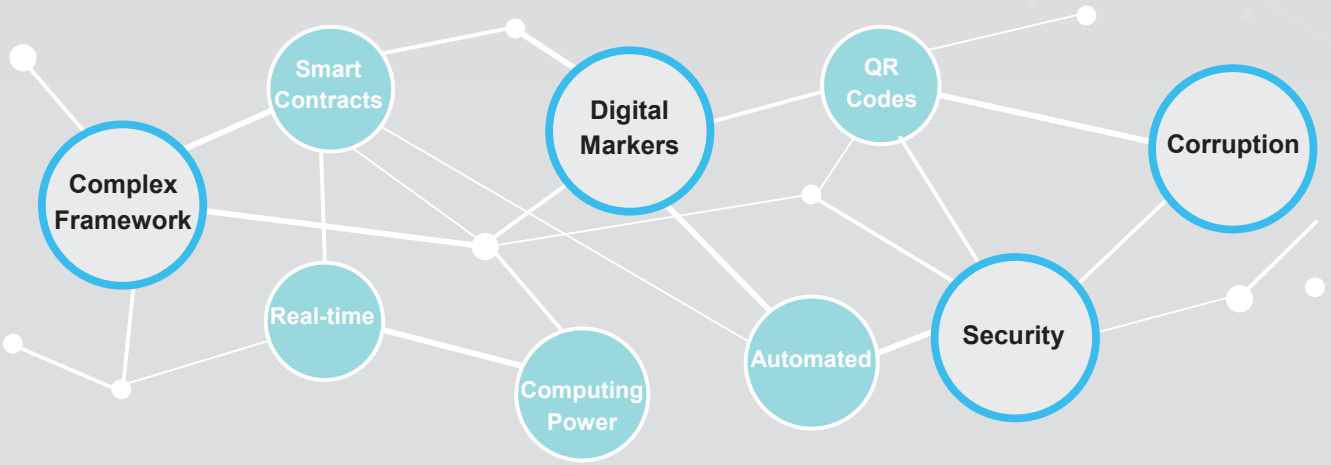
As the world becomes increasingly more interconnected, with the development of smart building technologies and connected communities, attention is being given to the security and capacity for such large connected system.

Connected Systems

Systems are becoming increasingly interconnected, with continuous innovations in smart homes and connected cities. While this improves efficiencies, it also poses increased risks.

What would this look like?

DLTs would provide a platform for reliability and security to be integrated into a connected system (from smart homes to connected communities) as the ledger ensures authentication and integrity of all devices within a specific system. This would involve coded smart contracts, identify verification (could involve biometrics) and automated validation.



Benefits

- Coding can provide security against malware or unauthorised users within an integrated smart system
- A distributed system would answer the 'bottleneck' issue

Problems

- Scalability: an IoT system would require fast processing, something that is a frequently mentioned issue with some blockchain/DLT applications
- Variability in the processing power of all the 'things' could cause the entire connected system to be slowed
- Legalities of the written code; if it were to fail, who would be held responsible

Discussion Themes

Throughout the workshop more generalised discussions around blockchain/DLT application were had. A number of prominent themes were apparent and are summarised below.

a. Private versus Public Blockchain/DLT

It is important to distinguish between the relative merits of private and public blockchains/DLTs, as this can be an important differentiation in how they function as a platform for each sector use. While both act as distributed peer-to-peer networks, one of the most evident and primary distinctions is to do with who is allowed to use it and therefore be part of the consensus.

Private blockchains do, however, lose that factor of removing the middle man and creating a trustless system. Instead, an organisation or governing body retain control, verifying all users of the system, increasing the efficiency within the blockchain (due to the removed crowding of the system as can be seen in public chains).

This distinction can make important differences in how an application within each sector could work. In an industry that relies on regulation and certainty in stakeholders, services and products, the scope for private of consortium blockchains is wide. Whether this would influence their uptake is worth further study.

b. Certification / Verification

Smart contracts form the basis of many of the discussed applications. One of the main concerns with this type of blockchain/DLT application are human error-related coding mistakes that can propagate within the system. To counter this there would need to be a way of verifying input content and certifying those adding to it. This could tie with the previous statement on whether the application is open or private. Privately run applications could employ a means of certifying users, while quality assurance procedures or the '51%' rule could be used to ensure code is correct or can easily be changed.

New technologies could develop that would interact with blockchain/DLT applications to address this issue. Artificial intelligence and sensing technologies could help reduce the element of human error and provide a means of automatically certifying and verifying application processes.

c. Hype versus Business Head

It takes a lot of effort and cost to get a blockchain/DLT application working, therefore it is necessary to carefully assess whether there is value in that effort and whether the final application is actually appropriate. The current climate around blockchain is full of hype surrounding its possibilities. While this may be well placed, we need to ensure we keep asking not 'what can we use it for?', but 'where would it be adding value?'; a point raised in the first workshop.

d. Industry Culture and Disruption

For any blockchain/DLT application to be successful it would need to appropriately navigate an industry that is notoriously reluctant to large scale change to established processes. Blockchain/DLT applications could be too disruptive. Without appropriate implementation certain sectors could feel alienated or threatened by it, particularly if applications lend themselves to creating anti-competitive platforms.

Education and regulation lies behind this potential problem. By better educating the industry on this subject area and ensuring appropriate regulation is in place many of the causes for reluctance could be negated.

e. Efficiencies – Sustainability, Energy and Effort

Fundamental to whether blockchain/DLT applications would be taken up within the industry is the sustainability and efficiency behind them. This relates to aspects such as costs, effort, energy use, value etc.

Currently large public blockchains require huge amounts of energy to mine and create blocks in the chain. For an industry that is increasingly focused on optimum efficiency and sustainability, this factor would simply not fit. Research into the value added, ways of minimised energy usage and waste, and potential sustainability improvements created needs to be carried out so this can be properly assessed.

Summary of Findings

Throughout the two workshops, and through further research into sector applications, it is evident that DLTs and blockchains are a complex group of technologies that could potentially be applied to a wide selection of built environment sectors in quite a diverse manner. Each potential application comes with a further set of questions and implications that warrant further investigation.

Blockchain itself is a relatively new technology that is still evolving and growing; what may not work quite yet for a given application may become a possibility in the very near future, making this a subject area that needs considered and constant attention.

There is potential for the creation of disruptive applications that could reinvigorate the industry and provide a means for further innovation. However, with that comes a whole new world of governance, legal implications and regulation that needs to be considered and developed alongside any application in order for it to be successful.

There is scope for much further discussion, research and demonstration regarding this subject area that looks to be growing in potential use, impact and public interest.

Further Research Themes

BRE is in a unique position for facilitating and driving further collaborative industry research into the role of DLTs and blockchain in the built environment. It is evident from the content of this report that there is a need for a significant amount of further research, both more broadly in terms of industry uptake and response, but also into how sector specific applications would function. As a result of this, some of the fundamental and apparent areas of greater focus are outlined below (in no particular order).

1. Value proposition

Two points have been continuously emphasised throughout this research piece, (i) that for many applications the greatest level of work required to implement a DLT/blockchain system goes against the value driven in the supply chain, and (ii) this is an industry that often blocks disruptive changes due to shorter-term impacts. Therefore, it is imperative focus is given to assessing how to best show stakeholder groups the benefits of DLTs/blockchains to both themselves and the wider sector.

All of the potential applications involve more than just one specific industry, level or stakeholder within the built environment sector; for example, the digital passports function by tracing elements throughout a buildings lifecycle, while responsible resourcing at its most fundamental level involves both recruiters and service providers. Therefore, future work developing these sector applications needs to focus specifically on the value propositions to each stakeholder at each and every stage of the DLT/blockchains use.

Mapping all stakeholders and interactors with a DLT/blockchain would establish the required groups that would be required for the successful uptake of the application. Engaging with these groups from the offset would enable the better creation and demonstration of value, while also helping to overcome issues relating to the blocking of disruptive innovations or the failure of applications due to one uninvolved party.

A series of research pieces focused on identifying and mapping the stakeholders associated with each of these identified sector applications and how these applications would alter their current working environment will enable more effective demonstration of value proposition.

Example – Digital Passport, Material Lifecycle Attributes

By nature, this application covers the entire lifecycle of a material/building, therefore the number of stakeholders that would interact with this DLT/blockchain application would be high.

Mapping these numerous stakeholders, from raw material sourcing and manufacturing, to maintenance and deconstruction, would help identify which parties could be a barrier to successful implementation. For example, while stakeholders involved in material recycling and waste minimisation may view this tool as an asset to their business model, those in manufacturing could be hesitant due to the potential pressures it could put on simplifying component parts and assembly. By mapping this out fully, a more detailed review of how this application would affect material product manufacturers can then be produced that would help establish where the value proposition could be for that stakeholder, i.e. CSR, potential new market in maintenance parts.

2. Unintended impacts

A lot of focus has been on the positive intentions of blockchain/DLT applications within the sector. Strategic research into the unintended impacts of application use, both beneficial and potentially damaging, would help develop the most appropriate solutions as well as presenting accurate value propositions.

While research into value proposition involves the mapping of all stakeholder groups, here there is a need to map all impacts, whether direct or indirect, associated with the use of a DLT/blockchain application. These impacts could be stakeholder specific or be a more general to the whole industry. By mapping these impacts, alternative applications could be created in the knowledge of less favourable impacts or potential barriers to implementation. This would save both time and effort and generate a greater trust in a technology many are sceptical or uneducated about; particularly in an industry that is typically averse to disruptive innovation.

Similar in form to a value proposition research piece, it would be valuable to assess each sector application area in relation to direct and indirect impacts to the various stakeholders, systems and industries the application could interact with, as well as the triple bottom line impacts (i.e. economic, environmental and societal).

Example – Resourcing, Labour and Skills

Focus has so far been on addressing the issue of modern slavery in the construction industry, however this application would theoretically be applied at a global level, therefore impacting all workforces, whether legal or illegal. Consideration into the wider impacts, for instance on SMEs, would need to be considered, as well as the financial implications of creating digital identities for all the workforce.

Mapping all the impacts at every stage of this application under various scenarios would help better establish both the positive and negative impacts of this application

3. Varied sector view

Current workshops have largely involved individuals professionally involved with the built environment industry with an interest in improving efficiencies and sustainability. This has enabled knowledgeable conversation about where these technologies can realistically have a role within the industry while also allowing for the relevant barriers to be highlighted. There is, however, a limit in that this has left a number of actions or barriers with a level of uncertainty; for example, all legal elements have so far been discussed with a limited background knowledge. Similarly, ideas around potential partnerships to enable successful application have been discussed from one side of the relationship.

To better understand all benefits and barriers before application design and application it is important all stakeholders are involved in these conversations. Similarly, we need to be having these conversations with those more sceptical about the technology in general, in order to best understand the barriers to implementation. These discussions would have to take place beyond the initial scoping stage; these stakeholders should remain involved through the full process of designing, creating and implementing specific DLT/blockchain applications.

Further to growing the stakeholder backgrounds, there is also a need to collaborate with other groups conducting similar exercises. Sharing of findings and information will better inform research and the development of applications.

Following a similar model as these first scoping workshops, an opening workshop to collect and review all perspective viewpoints could then be followed by sector application specific conversations based around the points raised in the opening workshop.

Prior to this an exercise in mapping out all relevant stakeholders needs to be carried out to ensure all relevant parties are brought into the discussion from the offset. This would involve a more general mapping of those impacted by the general introduction and application of this new technology area, in addition to those with an association with the more specific sector applications.

Example – Smart Contracts

Smart contracts inherently have a large legal element that needs to be better understood. In a system that still relies on human coding to establish 'if/then' clauses, where would the blame lie for mistakes? For this example, there is an evident need to involve legal professionals in these scoping stages.

In addition to this, there is a need to consult those in the industry usually involved in creating contracts and service agreements to see if this is a tool that would actually be of interest. As highlighted in the workshop discussions, many contracts are fostered on human relationships based on trust; using a 'trustless' system completely negates this element, which while providing a stronger guarantee, may be a step too far, too soon for many.

4. Trial and demonstration

Throughout these workshops a number of recurring questions were asked; "what would this look like?", "what would the measurable benefits be?" and "how do we engage others with this process?". One of the means for addressing these questions is through the worked demonstration of a DLT/blockchain application; creating a proof-of-concept with quantitative value-added evidence.

While this would achieve the aims of creating a working example of how an application could work and provide benefits, there is also scope for this to tie with the second focus area; unintended impacts. By working through an example, measuring all the impacts and comparing this with a baseline of the current way of doing things, we would not only be able to measure the intended benefits, but also quantify any unintended impacts, whether these are positive or negative.

Some of the above sector application lend themselves to this more readily than others. An application addressing labour sourcing would require a large-scale trial that may not be feasible in this early stage of investigation. The use of an application for one, or both, of the digital passport applications could, however, be achievable.

Example – Digital Passport

Using a standard building/demolition project as the basis for trialling a prototype DLT/blockchain would allow for comparison against standard procedures; measuring elements associated with materials sourcing/disposal and access to building and material level information (i.e. certificates).

Development of a basic tool that uses this technology will also enable people to better understand what the interface would look like, how it could be used, and how the data is stored.

By undertaking this trial, data can be collected on a whole range of factors, including quantitative elements of material waste and time taken, as well as more qualitative data on factors such as the satisfaction by clients and workers.

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