Constraints and benefits of the blockchain use for real estate and property rights

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Abstract

Purpose – Many recent social media posts and news may create a perception of big success in the use of blockchain for the real estate industry, land registration and protection of titles and property rights. A sobering outlook is crucial because misleading concepts may bury the whole idea of blockchain use. This paper aims to research the possibilities of blockchain and other distributed ledger technologies (DLT) and applicability of these technologies for different purposes in real estate, property rights and public registries.

Design/methodology/approach – This research is framed with policy studies and focuses on property rights, land registration regulatory framework and information and communication technologies innovations. The context of this paper is decentralization which has been developed in political science studies and the role of blockchain and DLT in it. Therefore, the provided analysis of blockchain and DLT is interdisciplinary research to interpret the facets of DLT technologies in the context of real estate and land title registration.

Findings – Permissioned and private DLT systems cannot be considered a significant evolutionary step in government systems. Blockchain, which is distinguished from permissioned systems as the technology of the immutable ledger that does not require authorities, is a new word in governance. However, this technology has some principal features that can restrain its implementation at the state level and thus require further research and development. The application of blockchain requires a proper architecture of overlaid technologies to support changes of outdated and mistaken data, address issues of digital identity and privacy, legal compliance and enforceability of smart contracts and scalability of the ledger.

Originality/value – This paper shows the constraints of the technology's properties which were not explained before in the context of title rights and land registration even though technological limits are known in more specific technical sources. Along with the known benefits this meant to help to avoid misinterpretation of some DLT features by non-technical people. A multidisciplinary approach in analyzing the technology and laws helped to better understand what can and cannot be beneficial for public registries and the protection of property rights. The presented outcomes can be laid down as requirements for the technical protocols aimed at addressing the issues of DLT and public policies to put blockchain at the service of society.

Keywords Real estate, Blockchain, Property rights, Smart contracts, Distributed ledger technology, Land registry

Paper type Research paper

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1. Introduction

Blockchain and other distributed ledger technologies (DLT) drew the attention of the real estate industry and governments. This research shows that there are no outstanding examples of success in the utilization of this technology in real estate and property registries. Therefore, this paper provides analysis and discusses the use of blockchain in addressing misconceptions and myths in this space.

The common feature of most of the projects is the idea of disrupting and decentralizing the real estate industry, developing, or improving land registries on blockchain, applying smart contracts and so on. None of the discussed examples however use public blockchains. This analysis shows there are no benefits in using centralized ("permissioned") DLTs for the public sector. At least, there is no justification found among such projects as to why certain centralized solutions are better than those which government agencies have already used for decades to run public registries. Inconsistency of ideas of decentralization and their implementation is a result of a lack of research and understanding of the technology's capabilities.

Even more alarming is a tendency for politicians and some startups to mislead society in their intentions to introduce any decentralized solution titling their technologies "permissioned" or "private" blockchains. The word "blockchain" is expected to correspond with inherent features of Nakamoto's invention – uncensored and public technology with an immutable ledger, with no dedicated trusted third party to conduct the system and provide a single source of truth for the state of transactions.

Sections 2 and 3 explore the constraints of the technology and its applicability to property rights and land registration issues.

Section 2 discusses the general ideas of blockchain use and decentralization, specifically, public ledger versus private/permissioned. The next section provides the analysis of issues in using public and private DLTs and some misconceptions. The fourth section shows some projects in the Republic of Georgia, Sweden, Ghana, The Netherlands, the USA and some other places and discusses practical issues that they encounter. The analysis shows that it is too early to make conclusions about these projects or at least they are not as enthusiastic as the perception media may have created. The cases should be further observed and scrutinized for an unambiguous assessment.

The conclusion summarizes ideas on the applicability and benefits of the technology in public services, particularly land cadasters and other property registries.

The value of this research is that it presents a systematic approach in the analysis of the use of blockchain for property rights and public services, considering that there is a lot of speculative and misleading information in media.

This paper contains a lot of technical discussions interpreted and summarized for a wide range of readers to fill a gap in the understanding of DLT and blockchain.

1.1 Theoretical framework and methodology

This research is framed with policy studies and focuses on property rights, regulatory framework of land registration and information and communication technologies (ICT) innovations. The context of this paper is decentralization which has been developed in political science studies and the role of blockchain and DLT in it. The provided analysis of blockchain and DLT is an interdisciplinary research.

This paper is draws conclusions from different sources:

- technical reports and white papers of projects, such as Bitcoin, Ethereum and Emercoin;
- academic papers; and
- technical analysis from forums and open industry platforms, mainly Bitcointalk and GitHub.

Media posts and social networks also provided some news on progress in the industry.

Questions found in subsection 3.2 are sourced from empirical data gathered by the author through participating in conferences, workshops and meetings around the world within industry and academia. This subsection is focused on addressing probable fallacies that may appear in the field.

The theoretical framework is not new and contains multiple developed concepts. In "The Evolution and Continuing Challenges of E-Governance" (Dawes, 2008), the author defines this field of knowledge as "the use of information and communication technologies (ICTs) to support public services, government administration, democratic processes, and relationships among citizens, civil society, the private sector, and the state."

The methodology which is used in this research is similar to such works as "The understanding of ICTs in public sector and its impact on governance" (Malinauskienė, 2013) and "Conceptual Framework for Context-Based E-Government Interoperability Development" (Jansen, 2012).

In the first paper (Malinauskienė, 2013), the author provides the analysis and generalization to define the concept of e-government interoperability. The researcher in the result of analysis of ICT capabilities and methods concludes that policymakers, public managers and related private sector organizations should assess the technical and evolutionary fitness of dynamic organizational capabilities for interoperability before starting any cross-organizational e-government initiative. It should be done through the analysis of related processes, asset position and path-dependency factors of all participating parties. The author recommends incorporating these principles of context analysis in the research of e-government.

In the second paper, the author (Jansen, 2012) asks if managers in the government really understand the many functions and roles ICTs have and how they should be governed. The author researches the phenomenon of mismatch of the functions implicit in the objectives that are stated for e-government and the way ICTs are governed. Jansen argues that this discrepancy can be attributed to an inadequate understanding of ICTs and its many functions. Jansen's conclusions became a methodological basis and leitmotiv for this paper.

The analysis provided by this paper is a typical preparation step before any policymaking while it also delivers grounds for further research and experimenting. Such analysis aims to bridge the complex matter of technologies to social science: law, management and economics. The outcome is a set of inferences for policymakers and researchers of the capabilities and limits of the technology.

2. Use of blockchain for real estate

A variety of ideas for using DLT for property rights recently appeared in the blockchain industry. However, speculation can make a reader think that blockchain has extraordinary features. Therefore, before designing any application it is important to understand what the technology can and cannot do.

Any abstract ideas in blockchain can be materialized in the existing features and services, which the technology can provide:

- *Cryptocurrency* is a unit of account in the blockchain network with no ways to double spend it. Cryptocurrency is an asset in the ledger, which is produced by users of the network as a result of some decentralized consensus mechanism, and then used as a transfer of value. Therefore, the user may own their "coins" in a wallet and transfer it as a digital cash. Technically cryptocurrency is a record attached to the address (public key) which can be managed by a private key. Public and private keys are elements of asymmetric cryptography (Schneier, 1996). Cryptocurrency can be used as payment in a property deed, i.e. a title in exchange for cryptocurrency. Cryptocurrency is also spent in

blockchains to run smart contracts, for example, to pay "gas" in Ethereum (Ethereum Wiki, 2017). Users also usually spend some coins as fees to miners during the transfer of cryptocurrency from one address to another.

- *Data insertion* into blockchain as the immutable storage became the subsequent useful property of the technology which the inventor (Nakamoto, 2008) has never explicitly mentioned as the fundamental benefit, but was always present as the essential feature of the technology. With a transaction, the user can insert some arbitrary data into blockchain. To insert data, the user must apply some specific scripts and methods in the transaction (Sward *et al.*, 2018). Data insertion may be useful for real estate to store data, which, in this case, becomes public and irrevocable. It is usually not used, as it is because the insertion of data became the fundamental feature beyond cryptocurrency, which made possible all further useful technologies, such as the colored coins (Colored Coins – Bitcoin Wiki, 2020), tokens (Ethereum Wiki, 2017), smart contracts [1] (Ethereum Wiki, 2017), name-value storage (Emercoin NVS – Emercoin Community Documentation, 2020) and decentralized applications (Raval, 2016). One the most known critical comments in the real estate industry of this feature is that inserted data cannot be altered; therefore, wrong and outdated information may mislead users. This issue is addressed by some methods which are further discussed.
- *Tokens* are records that first appeared as an overlaid technology on top of cryptocurrency or a part of a smart contract. However, a token can be a standalone record in the system, not related to any cryptocurrencies (EOS.WIKI, 2020). Also, cryptocurrency can be deemed as tokens themselves. A coin (for example, the smallest fraction – Satoshi coin) in the first generation of blockchains are used as a carrier of a token because all transactions are kept in the ledger, and each coin can be identified and traced, users may pull some external logic on it. For instance, some records of property rights which the coin can represent. Thus, a token is the record in the ledger that can be distinguished as a unique unit of account and attached to the address and therefore, owned by the user. Someone who has the relevant private key can use it to authenticate a transaction. The token is the technology around which users may establish legal relations by connecting the token to some property rights. Therefore, tokens for real estate play one of the most crucial roles.
- *Smart contracts* is a technology for automated transactions in a digital form [2] with some crypto assets (coins and tokens), in a broader sense in the second generation of DLT platforms smart contracts are programs that allow managing of crypto assets and automate transactions. For real estate, tokens and smart contracts are cornerstones since they allow digitizing of property rights and provide for online contracts.
- *dApps* (decentralized applications) is a broader understanding (than smart contracts) of a class of applications built on blockchain; dApps may consist of smart contracts but aim to provide a full range of end-user online services (Raval, 2016).

All speculations about the use of blockchain are limited to this list of services. It either can be used as cryptocurrency for payments, or as a storage for applications and records, including property rights and titles which can be managed by tokens and smart contracts.

Nevertheless, these things can be done with more traditional centralized electronic systems. The distinguishing feature that unites all this – a decentralized consensus. The consensus protocol is a logic of how these services are created and legitimized in the system.

2.1 Consensus and (De)centralization

The invention of blockchain aimed to provide the technology to maintain a ledger without authorities, i.e. a dedicated third party which provides the legitimate version of the database for other nodes in the network.

All nodes keep a copy of the ledger, while the consensus allows them to choose which copy is correct. The first designed consensus – Proof-of-work (Proof-of-work (PoW) – BitcoinWiki, 2020) – at a higher level of understanding is the mechanism of randomness. Nodes perform some calculations to find a new block and present it to the network as a legitimate piece of the ledger, and they do not know who is next to present a block.

In different consensus protocols, there are methods of how to increase the probability of getting this right, but they are still relative, and randomness is the key thing, and if this balance is broken, then the network becomes centralized – meaning there is someone who can dictate the right version of the protocol and database.

Centralization means the ability to change the protocol and effect the history of transactions, or even rewrite the blocks (especially in Proof-of-stake [PoS], which will be discussed later) and to censor incoming transactions.

In some discussions, especially among non-engineers, the consensus protocol is considered to be something which solves issues of the real estate industry. It should be emphasized that there is nothing else in the protocol besides the mechanism of randomness, aimed to provide decentralization in keeping records of cryptocurrency transactions, and the logic which is attached to it, i.e. tokens and smart contracts.

"Permissioned" and "private" shared ledgers are different from the idea of blockchain. Initially, they are designed as a centralized system where one node or a group of nodes can control the process of the creation of blocks and their validation.

Decentralization in public blockchains is not static. This is a dynamic process of competition of nodes which independently or collectively in a pool try to create new blocks and gain the right to write down a defined amount of cryptocurrency in these blocks as their reward. Therefore, "permissioned" is the worst scenario toward the running blockchain system.

Another essential feature of blockchain is a censorship resistance. The purpose of the technology is to ensure that any transactions and scripts defined in the protocol can be performed without any authorization. Users may also insert some arbitrary information in the allowed amount of data, for example, up to 50 kB in Bitcoin (Sward *et al.*, 2018).

To explain some misconceptions about the use of the permissioned DLT, let us provide some more technical details of the most typical consensus protocols.

In PoS (King and Nadal, 2012), the right to create a block is gained randomly as a lottery. Nodes can put their coins as the "stake" for the lottery against other nodes, the one who has a mathematically proven win, presents a new block, the node does not lose their staked coins, and may continue their play. The more coins a user has, the more chances to win. This protocol can be designed initially as centralized, at least, more than 50% of coins must be allocated ("pre-mined") in this case to one address in the genesis block, therefore, providing at least a 1 in 2 chance to create a new block or more if more coins are owned.

PoS can be used to develop a private DLT, so only a group of actors will maintain and use the network, for example to maintain the ledger that keeps records of property rights and transactions with them. Because no one has coins outside of this group, no one else beyond can perform transactions as well. However, this "peace" will be fragile, which means coin owners will not be limited by the technology from sharing their coins with someone outside of such a consortium. Thus, at any moment, such a group can fall apart, and the network becomes more decentralized and open for other users. So, how the private DLT

consortium keeps the ledger closed and private lies beyond the mathematics of the PoS. These are contractual relations of partners.

Another essential property of PoS is rewriting history. The actor can present the network with a new version of the chain beginning from any block in the past when the actor had enough stake to create a block. For example, history rewriting happened with Vericoin (Higgins, 2014). Here a general rule applies nodes accept the longest chain as legitimate. Therefore, when the controlling stake presents the longest chain, other nodes with minor stakes drop down the old version of the chain and consider the new one as the right one. This scenario is called "rollback" (Figure 1).

Therefore, the ledger is not immutable, and transactions are not irrevocable. The controlling stake owner will not necessary capture someone's coin, because they still will need the private key for any particular address, but they may drop off transactions from blocks, which means the attacked address will lose ownership over the coins (tokens, smart contracts).

Another centralized protocol for permissioned and private ledgers is *Proof-of-Authority* (PoA) (Wood, 2015). One actor in the system will provide the list of authorized addresses, which are allowed to create (validate) blocks. The supernode can arbitrarily grant and withdraw authorization to validators. Therefore, rewriting history is still possible when the supernode withdraws all access except one, which will rewrite the ledger and present it to the network.

Both protocols allow the pre-authorization of transactions. The validators will check and censor transactions before sending them to a new block. Therefore, rewriting history is considered the last measure.

PoS and PoA may be mixed with other consensus protocols, for example, with PoW or cast the snapshot (a hash sum) of the ledger from time to time to a more decentralized ledger

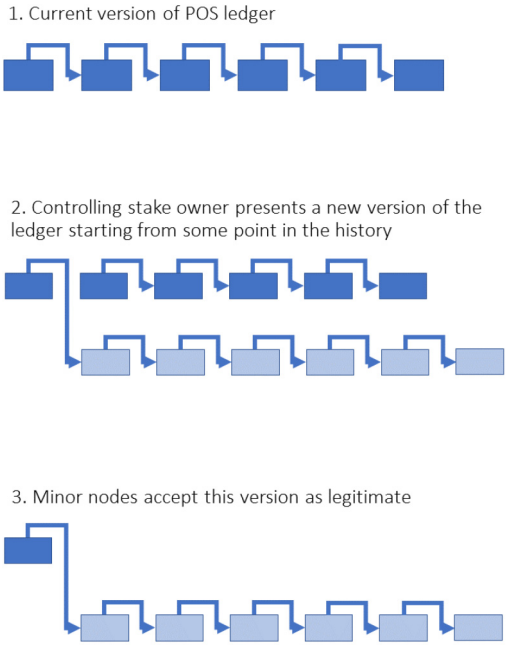

Figure 1.
Rewriting the ledger in "roll back" scenario in PoS consensus

(for example, Bitcoin). These measures can be used to add more credibility to the system. However, centralized remains as such, and these measures are considered as the goodwill of the owner, which can change their mind at any moment.

Interestingly, the Digital Transformation Agency of Australia in their report (*Blockchain Overview: Australian Government Guide*, 2018) noted:

> There are additional risks [besides those which are mentioned in NIST report] and considerations when using permissioned consortium blockchains, where leading users often in effect control blockchain. This usually removes the perceived benefits of decentralization.

The main conclusion of this analysis is that permissioned and private DLTs have no advantages against other centralized databases in terms of decentralization or at least, those who advocate these technologies did not provide reasonable arguments to support this technology against other centralized registries. It does not mean that the permissioned DLT is not applicable. It is a good technology for the private sector; however, for public administration and public services, this is questionable. Permissioned has a single point of failure, and users must delegate authority to the owner of the network and rely on their goodwill. This is relevant to other centralized technologies, more traditional databases, which have already been in use by governments for decades.

However, this discussion is not over, and more empirical research and analysis may provide a deeper understanding. Nevertheless, the very first question which must be addressed in using any DLT is the purpose. If the aim is decentralization, then blockchain is the answer. There is no other scalable technology for this objective that has been created before or after 2008 so far.

3. Issues with blockchain

Although the idea of decentralized governance is attractive, practical implementation is not viable at the moment. Some additional development at the technical level and, of course, at the political and legislative level is needed, which is discussed in this section.

3.1 Seven major issues

3.1.1 Immutability. There are two different conceptually designed DLT systems in terms of the consensus:

- initially decentralized and public (blockchain); and
- initially centralized are often referred to as "permissioned" and "private" (as a subset of permissioned).

However, as it is noted, decentralization is not a state, it is a process which also may end-up with centralization.

One of the essential advantages of using blockchain beyond the mentioned high-level ideas of decentralization, at the practical level, is *immutability*. In the ledger, users can store cryptocurrency transactions, and useful information not related to crypto at all. For example, records of property rights, title rights, etc.

Why an immutable ledger is better can be shown in the example of the loss of data by the Ukrainian government. The Ukrainian tax office lost a cluster of 3 terabytes of electronic records of tax returns and correspondence, more than half a million documents disappeared (*UNIAN Information Agency*, 2016), (The State Fiscal Service of Ukraine, 2016).

Public registries, which are controlled by centralized authorities, are an act of trust, where citizens usually have only one option; to decide during the elections whether they believe the government or not. But this will not return vital information when it is lost.

If we are talking about the record of a property right, especially if it is the only source of evidence, this is something that no owner wants to lose. Therefore, this risk shows how much the system with a single point of failure is vulnerable. Assuming no perfect organizational and technical structures, to be on the safe side, we should refer to Murphy's law [3], "Anything that can go wrong will go wrong," and act accordingly.

The bold promise of the government to serve the society fairly may be nothing if the technology does not limit embezzlement and corruption.

Blockchain as the technology, which excludes and minimizes human faults and corruption in providing an irrevocable and immutable ledger, is more competitive than the social contract based on pure political promise and trust.

Despite this fundamental conclusion and obvious benefits of the use of blockchain technology for keeping records of property rights, immutability creates obstacles that make this technology inapplicable unless a proper solution is found.

For example, the loss of private keys will make a cryptocurrency, a token, or a smart contract uncontrolled with negligible possibilities to ever restore it. Even if blockchain can prevent many ownership disputes, the imperfect nature of people's relationships will always cause issues with ownership, and the need to settle when they arise.

Blockchain itself, in its pure design, does not leave practical possibilities for enforcing any legitimate judicial decisions or any rightful actions by authorities because normally retroactivity is impossible and no one except the owner of the private key of the asset can perform a transaction.

Therefore, permissioned DLTs may be justified as the only possible solution, losing its initial properties of being immutable and censorless inherited from blockchain.

3.1.2 Permissioned VS public in terms of infrastructure. Public blockchain systems do not require authorities to create infrastructure. Their drive gear is cryptocurrency. Independent participants are incentivized to share their computing resources to the network and compete for the reward. The node, which presents a valid block to the network, has the right to include a record of new cryptocurrency. The protocol provides the amount of the reward which the node may assign; therefore, there are no authorities, which manage and maintain the system, it is self-organized and self-governed.

On the contrary, the permissioned system may require a central authority that is responsible for developing infrastructure, i.e. data centers, nodes, gateways, API, cybersecurity measures, etc. Therefore, with the ability to control and vary the ledger, comes the burden of infrastructure expenses and its centralization as well.

3.1.3 Hardforks. The government plays the role of a keeper of a traditional property registry. In different countries, they may have different names and specializations (cadastre, land title registry, real estate registry, etc.) but the purpose is the same: to provide certainty in property rights by tracking records of transactions (title deeds). It is similar to registries for movable properties (cars, boats, aircraft, etc.), shares and other securities and corporate rights.

The use of any decentralized system, including the blockchain is limited, because it may create issues with registry forking. The system can split into two or more branches or "forks" after which each branch becomes independent. In the result of the split, tokens are duplicated. For example, if the system is used to manage rights on movable property (often mentioned as "asset-backed tokens"), in the result of a hardfork, the user will still have one plot of land but two title records in parallel systems, which they can be managed

independently, thereby creating legal collisions. For example, in one system, the user sells the plot, but in the other, the user still owns it.

One possible solution is that the government will point out which blockchain is legitimate in the case of a hardfork. For example, Bitcoin or Bitcoin Cash, Ethereum or Ethereum Classic. Buy why would anyone use a decentralized system but end-up with the central authority? It also restraints competition between blockchains.

3.1.4 Anonymity (pseudonymity). The authorization and authentication for a transaction are provided only with the relevant private key, which belongs to the asymmetric pair. The public key of the pair is taken to generate the address of the transaction, and the address (to which coins are recorded) is the only public record in the system that identifies the user.

Some research showed that addresses could be deanonymized by different digital fingerprints, i.e. IPs, behaviour patterns, etc. (Ober *et al.*, 2013), (Androulaki *et al.*, 2013). The original blockchain protocol is not suitable for keeping records on property and securities from the perspective of governments and users themselves. Blockchain anonymity may veil money laundering, financing terrorism, and other unlawful activity.

Beyond that, at the practical level, the censorless nature of blockchain creates confusion in identifying records. Anyone may perform any transaction and publish any data in blockchain. If the government must authorize a land title deed, how do you define if any transaction on blockchain belongs to the town's clerk if they are all pseudonymous? Without overlaid solutions for digital identities and trust services [or more specifically, Public Key Infrastructure (Trček, 2006)], it is almost impossible to create any scalable model for governance.

3.1.5 Personal data. In blockchain and other DLTs which are open for reading, any published data is exposed, and removal is not an option. Therefore, ledgers are not suitable for storing personal data; users must at least have the right not to disclose their details. Otherwise, the right to be forgotten (GDPR) is not applicable. The use of DLT requires some technologies and methods for privacy preservation. For example, a cryptographic hash, published as immutable evidence in a DLT, will provide a one-way link to the personal data, but the data itself will be stored on the user's device or a closed third party's server.

3.1.6 Scalability. One exclusively chosen blockchain for governance will necessarily create issues. Again, because of the open nature, blockchain protocol does not restrain publishing junk data in the ledger. The potential bandwidth of Bitcoin per year, for example, is roughly 220 million transactions (Roio, 2013). For instance, more than three hundred public registries in Ukraine generate as much as Bitcoin's bandwidth (Data.gov.ua, 2020), which leaves no space for other cryptocurrency transfers. Overload with the transactions creates the problem of high transaction fees and price volatility. Although Bitcoin is not the best in terms of bandwidth, it is still the most attractive in terms of security (Cost of a 51per cent Attack for Different Cryptocurrencies | Crypto51, 2020). This is not a workable solution on a scale, even for one country with a 40-mln population, randomly chosen as an example.

3.1.7 Price volatility. Owing to speculations, the price can dramatically fluctuate, therefore creating a bad user experience for those who need cryptocurrency to pay fees for publishing and managing data, running smart contracts, etc. Together with the mentioned scalability issues, it makes it infeasible for the government to use, or even to announce their intention to use any specific blockchain. It will inevitably incentivize agiotage on the market, exacerbating the above-mentioned problem of scalability even more.

Eventually, as might be thought, the permissioned DLT is much better than blockchain as it addresses all these issues because of its centralized nature, purposed to control and restrict unwanted practices, and manually fix troubles.

This creates two basic misconceptions: centralized DLT is presented as an improved version of blockchain, able to address known limits. As we can see, it does, but this is not a blockchain (not decentralized, not censorless, etc.). The second is that one DLT is opposed to one blockchain.

It is proposed to create solidarity of reliable blockchains working in a bundle. The government should not choose one blockchain, but instead, provide an infrastructure solution based on common technical standards to support free competition of blockchain technologies. A market-driven approach is aimed at addressing the problem of scalability. The citizen, not the government, should decide which blockchain to use. The role of the government is to provide standards of security requirements (hash rate, etc.) for blockchain to exclude unreliable networks.

3.2 Misconceptions

There are a few major misconceptions in the use of blockchain technology. This subsection aims to address them.

"Immutability does not tolerate mistakes."

In the previous section, a general discussion is presented on the benefits and constraints of immutability. It is possible to suggest that immutably is something that prevents fixing mistakes. Let us clarify this position.

The mistaken transaction is irrevocable. Wrongly transferred coin matters. This is something that the sender cannot handle without the will of the receiver to refund back.

For example, one user mixed up the field which specifies the amount of coins to send with the filed he specifies the fee for this transaction. The user accidentally sent 2,100 ETH (US$300,000) as fee and would not get them back, unless the miner who received such a jackpot willingly returned (Insanity: Ethereum Wallet Pays Nearly $575,000 in Fees to Transfer $25 in ETH, 2020).

If we are talking about data insertion, immutability is not an issue. The mistakenly published information cannot be changed, but a proper architecture of the service can address it.

The solution is straightforward because timestamping is an essential feature of the system, all transactions are chronologically stored. The latest data inserted must be deemed as the correct one. Thus, even the user publishes inaccurate information initially, at any moment, they can update it by publishing corrected data. In the case where the user lost the private key and cannot publish an update from the initial address, then the architecture will require the involvement of a trusted third party. The user initially refers to the record of the validator. The validators will publish into blockchain a record (message) with the information about the validity of the target message (Figure 2).

Therefore, if the user lost the key, they will contact the validator and enquire to publish a message of invalidity of the target message. Of course, the validation must be performed in a machine-readable format to provide automation and better UIX. This technology and method are already in space, at least, since 2014, examples can be found in Namecoin (Namecoin.org, 2020), and Emercoin projects, pioneers in decentralized DNS systems (Loibl, 2014) and Name-Value Storage technologies (Emercoin NVS – Emercoin Community Documentation, 2020).

"How to include all title records of the country in the Genesis block?"

The issue is irrelevant in the case of developing the application of property rights on existing blockchains, for example, strongholds of public blockchains - Bitcoin, Ethereum,

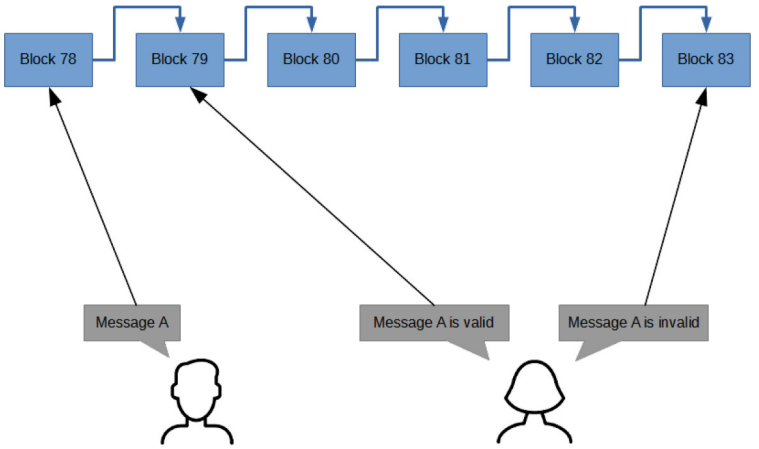

Figure 2.
Scheme for maintaining validity of records in blockchain

etc. However, these ideas may be discussed in the context of private and permissioned systems, which can be developed specifically to manage property rights and public registries.

The issue is as follows. If we build a new DLT where we initially would like to include all titles and other property rights records, which are currently in paper form or in the electronic land registry database, how do we deal with ongoing disputes and inheritance? There is no point in time when all deeds and disputes are settled.

The idea of moving all records to any DLT has some objections. There is a principle of *technological neutrality*, which means any technology may be applied, and the government should not prevent competition between technologies. Therefore, voluntary movement from one technology to another is a fallacy, the same as a fallacy as staying with the existing centralized technologies.

A better scenario is a free choice of every citizen in determining which technology to use to manage their property rights. And when this principle is ensured, citizens will be able to move their title records from papers and centralized DBs to blockchain. Therefore, there will be no starting Genesis block. This is a continuous process.

Ongoing disputes and uncertainty of some records can be addressed by the proper design of the technology, which must support algorithms for updating inaccurate or outdated records. Some of the existing methods are mentioned already in the previous question.

"Do we need a land registry?"

Free choice of technology requires returning to a higher level of understanding of what the "land registry" and "registration" themselves are. The purpose of the registry is to provide certainty in "who owns what." Therefore, the registry must ensure secure storage for records that are managed as per law. If the citizen has chosen to store the record in blockchain, there is no need to duplicate this record in the existing centralized land registry. Blockchain is the registry itself. Moreover, we cannot have two sources of truth for one title, otherwise such duplication will require protection from double spending and avoiding collisions of records in both systems.

Hence, the title record should be stored exclusively in one of the available ledgers.

"Title registration vs registration of deeds"

Different countries have their specifics of the registration of deeds and titles. For example, in the USA, there is a registration of deeds (*27 V.S.A. § 342, The Vermont Statutes*, 2020) [4]. Therefore, to check who is the lawful owner of the title, there must be a valid chain of registered deeds (*27 V.S.A. § 601, The Vermont Statutes*, 2020).

Torrens system [Australia and some other countries (Hepburn, 2018)] and most civil law countries use the system of registration of titles (European Land Registry Association: Description of land registration systems, 2020). The cadastral land identifier is connected to the record of the current owner of the title.

Blockchain includes *both* types of information: the token (i.e. title) is attached to the address (owner) that corresponds with the title registration, but the token is always the result of a transaction. Thus, the chain of deeds is also viable as a way of representing the land registry database. Therefore, blockchain technology has a dichotomous nature that corresponds with both title- and deed-centric ways of registration.

"Will the government be detached from providing registration?"

The government agency provides for the authenticity of the database. If the record of property rights and titles are tokenized, then there is no need for a public body to keep this registry. Once the record is in the database, there is no need for one specific authority to prevent the database from corruption. Nevertheless, the registration itself must be lawful, which is a job of public bodies and other intermediaries. The future development may include deep automation of procedures that will eliminate public servants and middlemen in real estate transactions.

"Will a notary public be excluded?"

In many countries, notaries public must acknowledge the contract with immovable property. Blockchain ensures only one of the functions of notarization, inter alia, the timestamp. Other aspects of notarization are not automated; therefore, it can be a matter of future research and development. Otherwise, the notary must authorize blockchain transactions. Hence, the architecture of the system must include this third party in the process of real estate deeds.

The requirement of acknowledgment may exist in other forms and roles. For example, town's clerk or master in Vermont state do a similar job (USA) (*27 V.S.A. § 341, The Vermont Statutes*, 2020).

"How to enforce smart contracts?"

Smart contracts are limited with the code, while normal contractual relations, even though they have some autonomy, are still interlinked with the existing laws. When parties interpret clauses of the contract, they first look at what the contract says, but if the issue is not regulated directly by the contract, law, precedents, and general business practice are applied. This is beyond the current possibilities of the technology of smart contracts. There is no framework for "smart law," and this is something which probably will be developed in the future.

However, at a practical level, the real headache of the smart contract is enforceability. If no third party is initially involved in the role of the arbitrator in the algorithm of the smart contract, the smart contract can get stuck in a dispute. This should be addressed by the component of the "authority" (judicial power, notary, etc.) in the system. At least one solution is conceptualized already. The cross-blockchain protocol (Konashevych, 2019) provides for a systematic approach in governing legal relations in the bundle of blockchains.

The protocol accommodates the concept of "smart law" as the framework for smart contracts.

"Who will become nodes-validators?"

This is a question in the context of applying permissioned DLT. Despite that, the issue of "permissioned" and "permissionless" systems is addressed in the previous sections and the use of permissioned DLTs when the government solely introduces it will be a game of one team on the ground. We must note that the question becomes more interesting if the government shares control with some other nodes.

How are those nodes chosen, and why must the government compromise their sovereignty with someone? Whomever they choose from the long list of credible companies and NGOs, there will be the questions why others who also deserve to share the control over the system are left behind, and why some entities, which are not a public body, are raised to the level of governance. This is a constitutional level of discussion, and there is no systematic approach found in addressing this issue.

At the same time, when public blockchains are used, there is no issue of nodes-validators. Anyone can have a node and freely compete in "mining." Blockchains, in this case, play the role of secure public repositories where information cannot be erased, and government agencies are validators not of the blocks, but validators of records (see Figure 2) which citizens insert in the ledger provided the insertion itself is not censored, but any user is free to apply for the government validation to provide for credibility of their records.

For example, the registry office of land titles will ensure that the user's token represents the property rights. So, the user can interact with a counterparty remotely. Even without knowing each other, the counterparty will know that this is a title record on blockchain, because they will see the assuring record from the government agency.

This structure seems to be more acceptable because two things are distinguished:

(1) blockchain as a decentralized infrastructure for reliable and immutable storage; and

(2) the role of the government in relationships that are built upon this infrastructure.

"Hashing records of the land registry"

Previous research (Konashevych and Poblet, 2018a) showed that this application is limited in terms of its benefits. Moreover, improper design may create even more trouble for security. The use of the centralized and decentralized system (blockchain) makes no sense because there will be an issue with this source of truth in the case of a discrepancy.

There are some other issues with hashing. There is a need to provide identification, authorization, and authentication because blockchain provides only for pseudonymous authentication.

Also, publishing hashes does not provide for a secure store of the initial data itself. The user must protect the record, wherever they store it off-chain. The centralized storage for such entries will always be a target.

Also hash publishing does not provide knowledge of the validity of the record. Usually, land registries' databases are closed systems, and an outside observer who sees only DLT, does not know if any public hash is authorized or not. The insider may illegally change the record in the database and reveal the hash as if it was retrieved from the valid record. To address this issue, the government requires more transparency and better design of the hashing method.

However, the main concern about this method is probably that it does not provide any basis for tokenization on blockchain; the property rights records are still exclusively stored in the centralized government database.

"What is a token: Title, Property right, Security, or a New Legal Concept?"

The token is just a record in the ledger. It does not necessarily have any legal side, the same as not every record on a piece of paper creates any legal relationship.

To make any sense, it must be based on the law and the contract. Therefore, to answer this question, the user must look inside the token (literally inside because some methods allow including legal text with the record) or behind the token. For example, many early projects like Colored Coins (Colored Coins – Bitcoin Wiki, 2020) were based on bitcoins, and the legal logic was developed beyond blockchain protocol as an overlaid technology.

The applicable law must also be a part of this analysis because when the jurisdiction provides for a certain way and form of performing some legal relationships, the creation of the token out of the existing legal framework makes it legally invalid or void.

Therefore, a title right or property rights will be valid in the form of a token, which is performed lawfully with regards to the jurisdiction where it is created, as far is it known, no jurisdiction has dedicated any legal framework for that.

It may also be found in some discussions that the token has a completely new legal nature. During the boom of Initial Coin Offerings (ICOs), 2016–2018, tokens were not company shares or traditional assets.

This is nonsense, and if the token does not represent any property right or obligation, it does not have any legal essence at all. This kind of ICO can be considered as fraud. However, in some cases, the token had a derivative nature (even if not called so), and so had a nature of a property right. For example, the token as a "square meter" in the future real estate appeared to be a right to convert this token to the actual record of ownership in the future.

4. Practical issues with implementation

This section provides a few examples of issues which arise at the junction of blockchain, governance and real estate industry. Media news may create a perception of a large disruption. This research shows no revolution is on the way. Nevertheless, it is not time to put an end to it.

4.1 Political will and corruption

Implementation of a game-changing project may not start unless the government has the will to start it. One of the earliest pieces of news in the field of the use of blockchain for land registry proliferated in media in 2015 from Honduras with the help of Epigraph and Factom Inc. Being referred to by many enthusiasts for a long time, the project itself was never kicked off (Jun, 2018). No evidence is found that the government has ever supported this initiative.

Here we find not a technological constraint but a political one. Countries that have issues with transparency of their public administrations, corruption and protection of property rights can significantly benefit from blockchain — a tamper-proof, transparent, public and decentralized database; but the introduction of such technology depends on their political will. Thus, we a vicious circle.

4.2 Does any prosperous society want changes?

Chromaway was founded in Sweden in 2014, giving the hope of disrupting the old-fashioned centralized and bureaucratized land cadaster. Two papers revealed details of the pilot (*The Land*

Registry in the Blockchain – Testbed, 2017) with the Swedish land registry authorities (and other partners) and "Chromia," former name is "Chromapolis" (Chromapolis Platform. White Paper, 2018).

Both documents advocate the use of the centralized "private" DLT assigning this technology attributes and features of blockchain which are irrelevant.

In 2019 the team showed their centralized DLT platform and revealed a lab prototype app for title deeds (Walk through – Swedish Land Registry Smart Contract – YouTube, 2019). The app requires a government agency and participating intermediaries to acknowledge a transaction between counterparties.

Here is unveiled the second significant misconception. In general, the problem of the architecture of such systems is that records have legal force when they are stored in the closed governmental database; all peer-to-peer transactions on blockchain between parties make no sense, as far the last word is on the side of the one who controls the central registry. Therefore, they need legislative changes.

Without shifting from centralized to a distributed architecture, any attempts of disruption turn into mimicking the existing system. Nothing more happens than digitizing bureaucracy and middlemen.

However, Chromaway teaches us another lesson. Over five years, the project did not succeed in introducing a working system at the state level. Prosperous and highly developed societies are often discouraged in changing their existing system. What for, if it works, though imperfect? It must make extraordinary sense for changes, especially at the scale of a whole country. And the Swedish government has no incentive to let go of its monopoly on political power over the centralized cadastral registry.

It is early to put an end and draw conclusions from the Chromaway initiative, therefore, further observation and study of the case will be required in the future.

4.3 Do the plans match the state of affairs?

None of the above-mentioned examples stated that they had failed. However, it is found in media some mismatch of public expectations and reality. White papers and projects' websites are used as sources for analysis of plans and intentions.

Bitland has been in Ghana since 2014 on a project to "register land and real property ownership and use rights" using blockchain (Bitland. Land Title Protection Ghana, 2020). The available updates on the website do not specify the stage of development of the blockchain infrastructure and achievement of objectives. Propy Inc., during its ICO in 2017, stated that their far-reaching plans were to disrupt the industry by eliminating third parties with a global real estate supermarket on blockchain, driven by smart contracts (Propy: The Global Property Store With Decentralized Title Registry (White Paper), 2017). However, their system at this stage has no connection to any land registry, and their demo is closed for public use; only private access is available upon requests. Both projects are claimed to be ongoing and further observations and case studies may provide more knowledge in the future.

REX, founded in the USA in 2016, promised a new multiple listing system (MLS) standard for real estate brokers. Eventually, they introduced IMBREX – online ad listing protocol for brokers and landlords (IMBREX White Paper. A Decentralized Real Estate Data Exchange and Real Estate Transaction Application, 2020). This example shows that blockchain may be useful for intermediaries and may not trigger the public sector. There is no information of mass adoption of this protocol, therefore, it is too early to say if the protocol found its wide applicability.

Velox.re demonstrated in Cook County, IL (USA) how hashing on a blockchain can be applied for land registry but ceased its activities in this direction (Velox.re, 2018). No

intentions to continue were found, and neither the land registry office nor Velox.re articulated reasons for that.

Bitfury, in 2018, launched their centralized DLT based on the Exonum DLT framework in the Republic of Georgia (Republic of Georgia to Develop Blockchain Land Registry – CoinDesk, 2020).

In Ukraine, they also had intentions to introduce a similar project but abandoned it [5].

As the case study explains (Shang and Price, 2019), the project did not set out to build a brand new blockchain-based land title registry system for the Republic of Georgia.

The project purposed to hash records of the real estate database on the centralized DLT, based on Bitfury's framework "Exonum." The benefits of the use of centralized technology are not justified, and the wider discussion on this issue was previously published (Konashevych and Poblet, 2018b).

However, another conclusion besides the concerns on a centralized nature of architecture is that hashing does not lead to tokenization of real estate titles and/or digitization of property rights, nor any changes in the traditional bureaucratic way of land registration.

The discussed in this section examples are often referred to in the industry and academia. Stated ambitions of the projects and optimistic opinions in social networks may create a perception of much success in the implementation. However, this analysis shows, the cases should be further observed and scrutinized for an unambiguous assessment.

5. Conclusions

This paper provided a broad overview of the use of blockchain and other DLTs in real estate, with the focus on title rights and property registration in public databases.

Speculation about the use of blockchain is limited to the list of services blockchain can provide. It can either be used as cryptocurrency for payments, or as a storage for applications and records, including property rights and titles which can be managed by tokens and smart contracts.

Nevertheless, these things can be done with more traditional centralized electronic systems. The distinguishing feature that unites all this – a decentralized consensus. The consensus protocol is a logic of how these services are created and legitimized in the system. The major element in blockchain that supports decentralization is the mechanism of randomness, where nodes compete for the right to create new blocks and to offer them to the network, known as mining, minting, staking, forging, etc. In different consensus protocols, there are methods of how to increase the probability of getting the right to create a new block, but they are still relative and randomness is the key thing; if this balance is broken, then the network becomes centralized – meaning there is someone who can dictate the right version of the protocol and database.

Centralization means the ability to change the protocol and effect the history of transactions, or even to rewrite the blocks and to censor incoming transactions.

Permissioned and private DLT systems cannot be considered a significant evolutionary step in government systems. Blockchain, which is distinguished from permissioned systems as the technology of the immutable ledger that does not require authorities, is a new word in governance.

However, this technology has some principal features that can restrain its implementation at the state level, and thus require further research and development. In particular, the application of blockchain requires proper architecture of the overlaid technologies to support changes for outdated and mistaken data (to overcome the problem of immutability), address issues of digital identity and privacy, legal compliance and enforceability of smart contracts, hardforks and scalability of the ledger.

The applicability of blockchain for real estate relationships, i.e. land registration, deed acknowledgement, and managing of property rights (titles) requires a systematic rethinking of the constraints and benefits of DLT technologies along with the purposes.

Tokens can represent land titles and other property rights. It makes no sense to distinguish tokens as title records from the transactions because they are technologically inextricable. Therefore, the land registry cannot co-exist with the blockchain as a standalone system. Blockchain is a registry itself. It indicates both: records of property rights (titles) and records of transactions (deeds). Therefore, blockchain fits both legal traditions of property registries, i.e. keeping title records (Torrens system and civil law) and keeping chains of deeds (common law system). It is clear that it is not possible to transfer the whole cadastral system to the blockchain in one night for various reasons (technological, political, organizational, legal). Instead, the traditional public registry and blockchain systems can work in parallel, and therefore, citizens will have the right to choose where they want to manage their property rights. This approach will ensure technological neutrality and competition of technologies. The role of the government in this case is to ensure high security standards and legislative support, because normally there is no such choice for citizens and the land registry is a monolithic centralized system. Future blockchain development and implementation may include deep automation of bureaucratic procedures that will eliminate public servants and middlemen in real estate transactions.

More empirical research and technical analysis is to be done to develop a substantial knowledge in this field.

Notes

1. Nick Szabo developed the idea of a smart contract in pre-blockchain period (Szabo, 1997).
2. The term "smart contract" is proposed by Szabo (1997).
3. Murphy's law is an adage or epigram.
4. Vermont state is chosen as an example.
5. According Viktor Vyshnov's report, General Director of the State Ukrainian Enterprise "SETAM", at Industry 4.0 & Blockchain Conference, www.blockchaingeorgia.org, September 28, 2019, The University of Georgia, Tbilisi, Republic of Georgia.

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