Constraints and Benefits of the Blockchain Use for Real Estate and Property Rights

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Abstract

Purpose - Within the hype in the blockchain industry and multiple examples of failed pilots in real estate, a sobering outlook is crucial; otherwise, these pilots and misleading concepts may bury the whole idea of the blockchain use. The paper aims to research the possibilities of the 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 paper analyzes possible scenarios and studies cases of the blockchain and DLT use for real estate and public registries and defines constraints of the technology and laws.

Findings - Permissioned and private DLT systems cannot be considered a significant evolutionary step in government systems. The 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the application of the blockchain requires a proper architecture of overlaid technologies to support changes of outdated and mistaken data, address issues of the digital identity and privacy, legal compliance and enforceability of smart contracts and scalability of the ledger.

Originality/value - The paper contains a case study and conclusions, which are valuable for further research and development in this space. A multidisciplinary approach in analyzing the technology and laws helped to understand better how to improve public registries. The presented outcomes can be laid down as requirements for the technical protocols aimed to address the issues of DLT and public policies to put the blockchain at a service of society.

Keywords – Blockchain, Distributed Ledger Technology, Smart Contracts, Land registry, Property rights

Paper type - Research paper

1. Introduction

The 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 cases of success in the utilization of this technology in real estate and property registries. Therefore, the paper provides the 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 to disrupt and decentralize the real estate industry, develop, or improve land registries on the blockchain, apply smart contracts, and so on. However, most of the pilots stalled at the level of ideas. Those who managed to develop a concept of the system architecture, or even presented their demo apps appeared to be centralized and mutable because they are based on the so-called “permissioned” or “private” DLTs. No benefits found in using centralized DLTs for the public sector. At least, there is no justification found among such projects; why this centralized technology is better than those which government agencies already use 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 capabilities.

Even more alarming is a tendency of politicians and such startups to mislead the 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, public, and decentralized technology with an immutable ledger.

The next part discusses the general ideas of the blockchain use and decentralization, specifically, public ledger versus private/permissioned. The third part provides the analysis of issues in using public and private DLTs and some misconceptions. The fourth part presents a case study in Honduras, Ghana, Georgia, Ukraine, Sweden, the Netherlands, and the US in attempts to utilize the blockchain for real estate. Based on the theoretical discussion in the previous sections, it is explained why these projects had no success so far.

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 in this field.

Here are some addressed questions in the paper: Is hashing on the blockchain useful for property registries? If we design a dedicated blockchain for real estate, how should we deal with the Genesis block, how can we include all title records in the country? How do we provide a reliable source of truth based on transactions and inserted data, which are immutable and can be incorrect? What is a token, and how can we use it for property rights? Do we need any conventional land (property, notary, deed, etc.) registry if we use the blockchain?

There are many ideas and concepts; some are valuable, while some are false or irrelevant, and some require more research and development.

2. The use of the blockchain for real estate

A variety of ideas for using DLT for property rights recently popped-up in the blockchain industry. However, due to the hype, a lot of speculations around these issues can make a reader think that the blockchain is a magic black box that contains an unknown world of endless possibilities.

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

- “Cryptocurrency” which is a unit of account in the blockchain network. 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 usually spend some coins as fees to miners during the transfer of cryptocurrency from one address to another.

- “Data insertion” into the blockchain as the immutable storage became the subsequent useful property of the technology which the inventor (Nakamoto, 2008) has never explicitly communicated as the fundamental benefit, but was always present as an essential feature of the technology. With a transaction, the user can insert some arbitrary data into the 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 as a way to store data, which, in this case, becomes public and irrevocable. It usually is 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”, n.d.), tokens (“Ethereum Wiki”, 2017), smart contracts1 (“Ethereum Wiki”, 2017), name-value storage (“Emercoin NVS - Emercoin Community Documentation”, n.d.), and decentralized applications (Raval, 2016).

- “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”, n.d.)). 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 a 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, therefore, owned by the user, i.e. who has the relevant private key can use it to authenticate.

1 Nick Szabo developed the idea of a smart contract in pre-blockchain period (Szabo, 1997).
a transaction. The token is a technology around which users may establish legal relations when some property rights are related. 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 property rights and provide for online contracts.

- **“dApps”** (decentralized apps) is a broader understanding (then smart contracts) of multiple applications built on the 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 the blockchain are limited to this list of services. However, there is another essential feature that unites all this – the consensus. The consensus protocol is a logic of how these services are created and legitimimized in the system.

### 2.1. Consensus and (de)Centralization

The blockchain invention aimed to provide the technology to maintain the 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 the 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”, n.d.) - 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’s 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, which will be discussed later).

In some discussions, especially among non-engineers, the consensus protocol is considered as 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 the blockchain. Initially, they are designed as a centralized system where a node or a group of nodes can control the process of the creation of blocks and their validation.

“Permissioned” is the worst scenario of a blockchain ledger evolution because 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. That is why, by the way, cryptocurrency does not appear from anywhere; it is a result of the creation of new blocks.

Another essential feature of the blockchain is censorless. 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, 8-50 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 **Proof-of-Stake (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 wins, presents a new block, the node does not lose their staked coins, and may continue their play. The more coins you have, the more your chances to win the right to present a new block. This protocol can be designed initially as centralized, at least, more than 50% coin must be allocated (“pre-mined”) in this case to one address in the genesis block, therefore, providing, at least, 1 in 2 chances to create a new block or more (if more coins are owned).

\(^2\) The term “smart contract” is proposed by Nick Szabo (Szabo, 1997).
PoS can be used to develop a private DLT, so only a group of actors will maintain and use the network, and because no one has coins out of this group, no one else beyond can do transactions as well. However, this “peace” will be fragile, which means technically, coin owners will not be limited by the technology to share their coins with someone outside of such consortium. Thus, at any moment, such a group can fall apart, and the network becomes more decentralized and open for other users. So, how does the private DLT consortium maintain the ledger closed and private lays beyond the mathematics of the PoS. These are contractual relations of partners.

Another essential property of PoS is re-writing history. The actor can present the network with a new version of the chain beginning from any block in the past when such actor had enough stake. For example, it happened with Vericoin (Higgins, 2014). Here applies a general rule inherited from the first blockchain. Other nodes accept the longest chain, which is presented by the node as legitimate. When the controlling stake presents the longest chain, other nodes with minor stakes drop down the old version of the chain and consider a new one as the right one. This scenario is called “rollback.”

Therefore, the ledger is not immutable, and transactions are not irrevocable. However, to change one transaction in the past, the node needs to change the whole subsequent chain, because the change of one bit causes the change of the hash of the block. The node may rewrite the targeting transaction if they have the private key for the address, they also may erase some or all transactions from the block, and then will create a new sequence of empty blocks which must be longer than the existing chain. It means that all that happened in the older branch of blocks will be lost. Some other scenarios of rewriting and effecting history are also applicable.

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. Technically, the supernode can arbitrarily grant and withdraw authorization. Therefore, rewriting history is still possible when supernode will withdraw all access except the one, which will rewrite the ledger and present it to the users.

Both protocols allow the pre-authorization of transactions. The validators will check and censor transactions before sending them to a new block. Therefore, re-writing 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 (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) notified: “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 the blockchain. This usually removes the perceived benefits of decentralization.”

The main conclusion to be articulated with this analysis is that permissioned and private DLTs have no advantages against other centralized databases in terms of decentralization. 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 are already in use by governments for decades.

Even though this discussion is not over, and more empirical research and analysis may provide a deeper understanding, but we believe 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 2008 or after so far.
3. Issues with the blockchain

Even though 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. Six Major Issues

3.1.1. Immutability

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

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

However, as it is noticed, 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 on 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, is 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, “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.

We infer that the blockchain as the technology, which excludes and minimizes human faults and corruption in providing irrevocable and immutable ledger, is more competitive against 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 the 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. The 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. Thus, it is considered that the only possibility to do this at the protocol level is the centralization of power. Hence, in this way, permissioned DLTs are “justified” as the only possible solution, making the blockchain helpless.

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

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3 Murphy's law is an adage or epigram.
a record of new cryptocurrency on the address, which the winning node chooses. 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 may require a central authority that is responsible for developing infrastructure, i.e. data centres, nodes, gateways, API, cybersecurity measures, etc.

3.1.3. 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 veils money laundering, financing terrorism, and other unlawful activity.

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

3.1.4. 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; at least, users must 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.

3.1.5. Scalability
One exclusively chosen blockchain for governance will necessarily create issues. Again, because of the open nature, the 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, 300 public registries in Ukraine generate as much as Bitcoin’s bandwidth (“Data.gov.ua”, n.d.), 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 51% Attack for Different Cryptocurrencies | Crypto51”, n.d.). This is not a workable solution on a scale, even for one country with a 40-mln population, randomly chosen as an example.

3.1.6. Price volatility
Due 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 the blockchain, as it addresses all these issues due to its centralized nature, purported to control and restrict unwanted practices, and manually fix troubles.

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

“Immutability does not tolerate mistakes”

In the previous section, we presented a general discussion on the benefits and constraints of immutability. At the practical level, many people think 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 address without the will of the receiver to refund back. 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 must 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 initially the user publishes inaccurate information; at any moment, they can update it by publishing a corrected data. In case the user lost the private key to 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. Validator’s message will include information about the validity of the target message. 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 methods are already in space, at least, since 2014, examples can be found in Namecoin (“Namecoin.org”, n.d.), and Emercoin projects, pioneers in decentralized DNS systems (Loibl, 2014) and Name-Value Storage technologies (“Emercoin NVS - Emercoin Community Documentation”, n.d.).

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

The issue is irrelevant in case of developing the application of property rights on existing blockchains, for example, strongholds of public blockchains - Bitcoin, Ethereum, etc. However, these ideas are 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 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 move from one technology to another is a fallacy, the same as a fallacy to stay dominantly 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 the blockchain. Therefore, there will be no starting Genesis block. This is a continues process. Ongoing disputes and uncertainty of some records can be addressed by the proper design of the technology, which must support updating inaccurate or outdated records. Some of the existing methods are mentioned already in the previous subsection.

“Do we need a land registry?”

Free choice of technology requires returning to a higher level of understanding of what is the “land registry” and “registration” themselves. 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 the blockchain, there is no need to duplicate this record in the existing centralized land registry. The blockchain is the registry itself. Moreover, we can’t 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 U.S., there is a registration of deeds (27 V.S.A. § 342, The Vermont Statutes, n.d.). 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, n.d.). 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”, n.d.). The cadastral land identifier is connected to the record of the current owner of the title.

The blockchain includes both types of information: the token (i.e., title) is attached to the address (owner) what 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 dual nature that corresponds with both title- and deed-centric ways of registration.

“Is the government 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 in 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.

“Is the notary public excluded?”
In many countries, public notaries must acknowledge the contract with immovable property. The 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 the blockchain transaction. Hence, the architecture of the system must include this third party in the process of real estate deeds. Acknowledgment issues may be relevant for systems where other roles are present, for example, town’s clerk or master in Vermont state (U.S.) (27 V.S.A. § 341, The Vermont Statutes, n.d.).

“How to enforce smart contracts?”
Smart contracts are limited with the code, while normal contractual relations, even though they have some autonomy, they still are 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 state of the art of the technology of smart contracts. There is no framework of the “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 (Konashyvych, 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 are 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 are chosen, and why the government must 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 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 the counter-party remotely, even without knowing each other because the counter-party will be assured with the record which they trust, i.e., the government agency. This structure seems to be more acceptable because we distinguish two things: (1) the blockchain as infrastructure for reliable storage, and (2) the role of the government in relations that are built upon this infrastructure.

“Hashing records of the land registry”

Previous research (Konashevych and Poblet, 2018) 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 this source provides truth in case of discrepancy.

As to specifically hashing on the blockchain, there are other issues, and there is a need to provide identification, authorization, and authentication because the blockchain provides only for pseudonymous authentication. Also, publishing hashes do not provide for a secure store of the initial data itself. Therefore, the centralized database will always be a target. Another issue is the better design of the system because publishing hash does not provide knowledge of the validity of the records, which are hashed. Usually, land registries databased are closed systems, and an outside observer who sees only DLT and published hashes there does not know if the public hash is authorized or not. The insider may illegally change the record in the database and reveal the hash of a valid record. To address this issue, the government requires more transparency and better design of the hashing method.

But probably, the main concern about this method is that it does not provide any basis for tokenization.

“What is “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. It must be based on the law and the contract. Therefore, to answer this question, the user must look inside the token (literary, 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”, n.d.) were based on bitcoins, and the legal logic was developed beyond the 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 relations, 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 provided any legal framework for that.

It is also may be found in some discussions that the token has a completely new legal nature. During the wave 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 was a
derivative nature (even if not called so), or 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. Case study

4.1. Land registry in Honduras

The first news of the use of blockchain for land registry proliferated 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). And here we find the first fundamental constraint, though not a technological
one: countries that have issues with transparency of public administration, 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 the political will.

4.2. Chromaway in Sweden

Chromaway was founded in Sweden in 2014, giving hope of disrupting the old-fashioned centralized and
bureaucratized land cadastre. However, 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 “Chromapolis” (“Chromapolis Platform. White Paper”, 2018)). Both documents advocate
the use of the centralized “private” DLT assigning this technology attributes of the blockchain what is
irrelevant. In a YouTube demonstration in 2019 (“Walk through — Swedish Land Registry Smart Contract
- YouTube”, 2019), the team showed their centralized DLT platform, which is not a blockchain like any
other permissioned DLT platform, and revealed a lab prototype app for title deeds. The app requires a
government agency and participating intermediaries to acknowledge a transaction between counterparties.

Here is unveiled the second most 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 the 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 often fail to find
reasons to change the 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.

4.3. Bitland, Bitfury, IMBREX, Velox.re and others

Bitland has been in Ghana since 2014, and the project has never delivered its objectives to “register land
and real property ownership and use rights” using blockchain4 (“Bitland. Land Title Protection Ghana”,
n.d.). Propy Inc., during its ICO in 2017, stated that its far-reaching plans were to disrupt the industry by
eliminating third parties with a global real estate supermarket on the 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).

REX, founded in the United States in 2016, promised a new multiple listing system (MLS) standard for
real estate brokers, ending up with IMBREX - online ad listing protocol for brokers and landlords — and,
if we forget about the high-level idea to get rid of the enormous amount of middlemen in real estate, it looks
like a success (“IMBREX White Paper. A Decentralized Real Estate Data Exchange & Real Estate
Transaction Application”, n.d.).

4 The author of this paper interviewed L. Bates, Bitland co-founder.
Velox.re demonstrated in Cook County, Illinois (U.S.) how hashing on a blockchain can be applied for land registry but ceased its activities in this direction (“Velox.re”, 2018). Bitfury launched in 2018 its centralized DLT based on the Exomun DLT framework in the Republic of Georgia (“Republic of Georgia to Develop Blockchain Land Registry - CoinDesk”, n.d.). In Ukraine, they also had intentions to introduce a similar project but abandoned it. The project purposed to hash records of the real estate database on the centralized DLT. The benefits of the use of centralized technology are not justified.

5. Conclusions
The paper provided a broad overview of the use of the blockchain and other DLTs in real estate, with the focus on title rights and property registration in public databases. Permissioned and private DLT systems cannot be considered a significant evolutionary step in government systems. The 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 the blockchain requires a proper architecture of the overlaid technologies to support changes for outdated and mistaken data, address issues of the digital identity and privacy, legal compliance and enforceability of smart contracts and scalability of the ledger.

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