BLOCKCHAIN-BASED LAND REGISTRY: PANACEA, ILLUSION OR SOMETHING IN BETWEEN?

Legal interference of Registrars in the e-conveyancing process[1]

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Summary

In this paper the functioning of blockchain technology and the possible use or impact it may have on current Land Registry systems and the role of legal experts are described. October 31st 2015, the Economist wrote an article[2] about the use of Blockchain as a 'Trust Machine', stating: "The spread of blockchains is bad for anyone in the "trust business" (…), such as (…) government authorities that are deemed sufficiently trustworthy to handle transactions". It was stated that land registries across much of the world are "badly kept, mismanaged and/ or corrupt". Blockchain technology should prevent the insecurity and injustice that are part of these land registries. The shared ledger technology should bring trust. Will this truly be the case? And will it be possible to replace well-functioning Land Registration systems (that are not corrupt and are kept and managed the proper way)? Will a blockchain-based system be less complicated and less expensive than the current well-functioning Land Registration systems? This study does only include developments until October, 31., 2016. It therefore does not describe or comment on more recent developments.

1. Land Registers: Object – Right - Subject

The common pattern for Land Registration (systems) consist of a triple: Object (spatial unit) – Right (*rights in rem* or personal rights) – Subject (the title holder of the right that is related to the object). This triple is the basic structure for all well-functioning systems. It is not without coincidence that – amongst others – the key principles of the conceptual model for Land Administration, the Social Tenure Domain Model (STDM), for building a legal and regulatory framework are a *continuum of land rights* (rights, restrictions and responsibilities), a *continuum of land use right claimants* (persons

[1] This paper is an adaptation from the paper, presented at the IPRA/CINDER congress earlier this year in Dubai.
[2] See: http://www.economist.com/news/leaders/21677198-technology-behind-bitcoin-could-transform-how-economy-works-trust-machine (last accessed October 30 2016).

and groups or entities) and a *continuum of spatial units* (land, objects and units)[3][4]. This triple is also knowns as the ABC-structure, as this structure has (also) been identified during the IMOLA project, the project by which the European Land Registry Association aimed to produce a model for standardised land registry output, connected to explanatory material in different languages.
In the IMOLA project ELRA has implemented Reference Information Fact Sheets to explain the meaning of Land Registry information in context and into detail. The ABC-structure is containing all information with regard to the object, the subjects involved, the most embracing right in rem (mostly: ownership) and the applicable other rights in rem, burdens and easements. In section A the Land Registry Unit is defined, in section B the Proprietorship is described and in section C the Encumbrances are explained into more detail.

2. Complexity in Land Registration: 'bundle of rights'

Things start getting complicated in case of plurality within each of these three parts of the triple. The most complex, yet not inconceivable situations are the cases where two or all three items within the triple are complex and/ or used in extraordinary cases. The *'bundle of rights'*[5] can cause a lot of complexity, especially when combined with different shares in various rights. An example of this complexity is a case where there are multiple persons, each entitled to different shares in various rights (e.g.: a right of bare ownership, encumbered with the right of usufruct and a building right), with a mortgage right or seizure on the right of ownership or the building right, with regard to a building on a plot of land (parcel), which building has been divided into apartment rights. Will this fit in a Land Administration that is based on Blockchain technology? To answer this question I start by explaining what Blockchain is, what it does, what it needs and what elements and/ or actors possibly can be left out a Land Administration system.

[3] Lemmen, C., (2012). A Domain Model for Land Administration. Delft University of Technology, Delft, The Netherlands (PhD thesis).
[4] This triple is also knowns as the ABC-structure, as this structure has been identified by the IMOLA project. The European Land Registry Association (ELRA) has worked closely with other associations and networks concerned in the area of Land Administration. With this project ELRA aimed to produce a model for standardised land registry output, connected to explanatory material in different languages.
[5] The 'bundle of rights' is a common way to explain the complexities of property ownership. It is commonly taught in Common Law systems. These rights are the recognized rights of the holder of title to the property and include: the right of possession, control, exclusion, enjoyment and disposition.

3. The concept of Blockchain

The concept of Blockchain technology can be divided into three different concepts:

a. An organisational concept: blockchain technology is aimed to cut costs and to make the use of Trusted Third Parties, such as Notaries, Banks and Governmenatl organisations superfluous. It is meant to give individuals control on the processes in the blockchain, without the use of a man-in-the-middle. In well-functioning Land Registry systems there are reliable Trusted Third Parties involved in the transfer of ownership of immovable property. Because of the design of the process of transfer of ownership in these systems, the legal certainty is guaranteed and rightful claimants are protected. Apart from the registration of transactions, there is also a relationship between the transaction and the reality, the actual situation. It is questionable whether Blockchain technology can perform these elements as well or replace a well-functioning Land Registry, especially in cases where Land Registries are well-functioning and trusted by its users. In countries where there are no such (reliable) registries, the use of Blockchain technology perhaps seems more appropriate. This is why the use of blockchain is examined, amongst other countries, in Honduras[6] and Ghana[7].

b. A concept of design: the creation of a reliable and accessible and/or public administration containing all kinds of transactions using the capabilities of the network organisation (just like the structure of the Internet, a network without a single point of failure). Blockchain technology offers a complete new perspective on how to keep a registration and to make information accessible (in a registration). This approach fits the self-reliance and it is interesting to take into account when designing new registrations, although there are not many Blockchain-based applications, especially in Land Registration matters, and little is known about potential drawbacks of this concept. In the Netherlands, Dutch Kadaster is doing some research on the use of Blockchain in cases of sharing specific data sets, concerning open data. If the technique seems fit for this purpose, these data sets will be put on blockchain, so everybody using these open data sets can see the dataset is put on the blockchain by (and therefore derived from the cadastral and land registry information from) Kadaster.

c. A technological concept: a technical solution to situations where multiple parties can perform transactions. There is a need for a decentralized solution that ensures reliability and consistency of information. There are several implementations of blockchain that may offer useful functionality. These applications possibly can provide opportunities to simplify current

[6] Although the developments seems to stall due to the politics of Honduras, see: http://siliconangle.com/blog/2015/12/27/factoms-blockchain-land-reigstry-tool-trial-stalls-due-to-the-politics-of-honduras/ (Last accessed on October 31., 2016).

[7] See: https://www.google.nl/?gws_rd=ssl#q=ghana+blockchain+land+registry (Last accessed on October 31., 2016).

IT systems, underpinning and supporting a Land Registry system. Perhaps it is possible to realize new functionality at lower costs and with reduced complexity. At this moment Dutch Kadaster is working on a proof of concept for a blockchain-based method of signing and sending (or uploading) notarial deeds to the Land Registry office.

Bitcoin is the first and most known application of blockchain technology. It combines all three characteristics, it diminishes the role of the traditional banks and it ensures that the reliability is organised into a network and it provides a technological solution.

4. The functioning of Blockchain

In 2008 an announcement[8] was made and a paper[9] was published on The Cryptography Mailing List at metzdowd.com by a (group of) member(s) under the pseudonym[10] Satoshi Nakamoto, describing the bitcoin digital currency. In 2009 the first Bitcoin software was launched.

Later on Nakamoto handed over control of the source code repository and network alert key to Gavin Andresen[11] and left the Bitcoin Community in secrecy. Since then the Community has expanded with new developers, working on Bitcoin[12]. Although the real identity of Nakamoto is still not known, the used technique is open source. That is the reason why it does not seem to be very important who Nakamoto really is[13], although he, she or the group owns a *wallet* containing roughly one million bitcoins.[14]

Blockchain is a technological solution to register transactions without the services of a Trusted Third Party. It is a type of consensus-based computing that facilitates Bitcoin and other services. It is often said banks, governmental parties, Chambers of Commerce and Land Registry authorities should keep an eye on Blockchain. It is even said these parties (perhaps) will be challenged (or even replaced) by this 'disruptive technology'.[15] Various interested professional parties[16], including banks[17] and Land

[8] http://article.gmane.org/gmane.comp.encryption.general/12588/ (Last accessed on October 31., 2016).

[9] The text of the original publication, "Bitcoin: A Peer-to-Peer Electronic Cash System", can be found here: https://bitcoin.org/bitcoin.pdf (Last accessed on October 31., 2016).

[10] S., L. (2 November 2015). "Who is Satoshi Nakamoto?". *The Economist explains* (The Economist), Davis, Joshua. "The Crypto-Currency: Bitcoin and its mysterious inventor.". *The New Yorker*.

[11] Bosker, B., *Gavin Andresen, Bitcoin Architect, Bitcoin Architect: Meet The Man Bringing You Bitcoin (And Getting Paid In It*), HuffPostTech.

[12] Where Bitcoin is written with a capital 'B' I mean the blockchain. In all other cases with 'bitcoin' is meant the asset. "Bitcoint" the blockchain is conceptually independent from "bitcoin" the asset.

[13] A brief overview of articles and other sources, conducting research on the identity of Nakamoto can be found at https://en.wikipedia.org/wiki/Satoshi_Nakamoto (Last accessed on October 31., 2016).

[14] Owning a wallet with this amount of bitcoins could form a risk. Since it is such a high percentage of the total amount of bitcoins, the owner of this wallet could influence the value by selling the whole package of bitcoins.

[15] Although the technology is described as being disruptive, the used techniques themselves are not new. The technology exists of a mixture of five elements, that are already existing since the `70`s, `80`s and `90`s of the previous century. Yet, no one had combined these techniques in this particular way. The novelty is its architecture and the design characteristics that make it work.

Registry organisations[18], are examining and exploring the possible practical use of this technique. Blockchain has been described by analogy with the (old paper) process as a ledger. It is a method of recording data – digital ledger of transactions, agreements, contracts – anything that's needs to be independently recorded and verified as having happened.[19] It knows who owns what at a certain time. It keeps track of transactions, it knows when a transaction took place and it ensures that there is always one single owner and no double usage of the same item or unit.

The phenomenon called blockchain has the following characteristics:

1. Shared databases. A blockchain is a shared database, copied on multiple databases that are all connected to each other. In the world of Land Registry it is common to use one source, one database with some back-up facilities.
2. Multiple writers. In a blockchain each and every transaction can be put in each version of the database. In the world of Land Registers, the transaction is updated in only one system. A copy of this transaction will be recorded in the back-up systems.
3. Distributed trust. Unlike existing Land Registry systems where the administrator is trusted, you don`t need to trust the administrator of a copy database. Blockchain is also described as *'shared single source of truth*'.
4. Disintermediation. It is possible for anyone to keep a copy of the database and execute a transaction on that database. In the current Land Registry systems there is always a trusted third party that updates the registration.
5. Transaction dependency. In a blockchain it is possible to create a dependency on another transaction. The blockchain can monitor the fulfilment of this dependency.
6. Timestamping. In blockchain it is possible to securely keep track of the creation and modification time of a document or transaction. No one, not even the owner of the document, is able to change the (content of the) document or transaction once it has been recorded, provided that the integrity of the timestamp facility is never compromised.
7. Transaction rules. To prevent any undesirable transactions taking place, blockchain can check whether the transaction is valid or not. In traditional (Land Registry) systems the Trusted Third Party is monitoring the validity of the transaction.
8. Validation. Blockchain logs all validated transactions in a sequence. It is a public register and unchangeable and therefore indisputable. In current Land Registry systems all transactions are part of a ledger and are traceable using an audit trail of some kind (validation).

[16] For example, the US state of Vermont is testing a blockchain to store government records, while the central American nation of Honduras is testing a blockchain for property transactions.
[17] The most well-known initiatives initiated by financial institutions is the R3 consortium, see: https://r3cev.com/ (Last accessed on October 31., 2016).
[18] Amongst others, Sweden, Georgia, Honduras, Ghana and Chicago`s Cook County, are developing, testing or creating a blockchain-based Land Registry.
[19] http://www.bbc.com/news/business-35370304 (Last accessed on October 31., 2016).

9. Scalability. The Blockchain is easily expandable. Everyone who would like to upload a transaction on the blockchain can do so.

This truly seems to be an ideal and unique functioning system. But is this underlying technology really unique and ideal? Can Blockchain be used in various cases? And would it be possible to run a land registry system on the Blockchain technology?

5. The technique of Blockchain

The technique behind the blockchain consists of two main parts:

1. A distributed ledger. This ledger is a database with the complete history of transactions.
2. A peer-to-peer network (P2P network). Such a network is to be described as a decentralised communications model in which each party has the same capabilities. Either party can initiate a communication session. The P2P network allows each connection point (peer) to function both as a client and server.

These two parts combined create a *distributed ledger*, using several other (already existing) items or techniques, such as SHA-256[20] and *hashcash*[21]. Timestamps, ledgers and digital signatures have been around for many years, but the combination has unlocked the opportunity for many new and consequential innovations.

The beginning of this 'history of transactions' is a first block which is called the *Genesis-block*. This first block is basically an empty state which everyone can agree on. This block (and all the transactions that are made afterwards) is saved in the 'database'. The database is shared on various computers that are linked ad random to other computers. These computers are called *nodes*.

To explain the way blockchain works, it is useful to refer to the use case of crypto-currency. The most common known is the Bitcoin. Strictly speaking, bitcoins do not exist. They are not tangible. There are *records* of transactions between accounts[22]. These accounts, called *wallets*, are expressed in bitcoin addresses which are generated at random and consist of numbers and characters. That way, these

[20] The SHA256-algorythm is also used for signing documents with a qualified electronic signature. It produces a 256 bit *hash* from (any) data, as a fingerprint of that data.

[21] *Hashcash* is a proof-of-work algorithm that requires a selectable amount of work to compute, but the proof can be verified efficiently. For email uses, a textual encoding of a hashcash stamp is added to the *header* of an email to prove the sender has expended a modest amount of CPU time calculating the stamp prior to sending the email. (source: https://en.wikipedia.org/wiki/Hashcash. Last accessed on October 31., 2016).

[22] Bitcoin is a medium of exchange. In the Netherlands it is not seen as a legal currency, see: ECLI:NL:RBOVE:2014:2667, as discussed by Rank, W.A.K. (2015), *Betaling in bitcoins: geld of ruilmiddel, betaling of inbetalinggeving?* ("Payment in bitcoins: money or medium of exchange, payment or tender payment?"), Ars Aequi, p. 177-186. The European Court of Justice gave a preliminary ruling afterwards in another case, see: ECLI:EU:C:2015:718. The Bank of America is of the opinion that bitcoin has potential to become a legal currency, see: https://www.documentcloud.org/documents/885843-banks-research-report-on-bitcoin.html. (Available in the Dutch language only. Last accessed on October 31., 2016). In Germany bitcoin is a legal currency since 2013.

accounts can be created immediately and completely anonymous.[23] These wallets are secured by using encryption technology, as is done using a qualified electronic signature. The owner of the wallet is using his or her private key to sign the transaction. After that the transaction is begin placed on the network. The balance of these accounts can increase or decrease.

Once a transaction is created, it is broadcasted through the P2P-network by using the *nodes*. Because of the P2P-technology it is very difficult to find out who sends the transaction. This is where the technology differs from most registrations: trust is not needed (at this stage), the technique itself will bring trust by *mining* the transactions. The transaction will be added to a *pool* of pending transactions. Because of the (bitcoin)protocol the balance of the wallet cannot be retrieved at once. For this, older records in the blockchain have to be collected.

Blocks that are containing pending transactions are created approximately every ten minutes. It is done by creating a *hash* value on the pool of transactions. This is called *mining*. When adding a block to the network an order to the various transactions within the block is established and a cryptographic signature is added to the block. A cryptographic signature has two main characteristics. Both are critical to the security of the database. First of all, the signature establishes a link to the preceding block. The second important characteristic of the signature is the non-repudiation: if the order or a transaction itself within the block would change, the signature will not be the same any longer. This will be noticed within the network that encompasses this block. If any transaction in a block – or perhaps in the Genesis-block –changes, the signatures from all blocks following that change will also be(come) invalid. This means that Blockchain establishes an unchangeable permanent record of changes to the database.

When a new *node* appears in the network, it connects to the other *nodes*. These existing nodes update that new node with the history of the database, so the new node is capable of presenting the history of all transactions, coming to the same conclusions as all other nodes in the network.

[23] The anonymity is not guaranteed. For instance bitcoin is not as anonymous as ready money/ cash is. By using the blockchain technology a public key is published. It is possible to associate many public keys with each other, and with external identifying information. With specific tools the activity of known users can be observed in detail. By filtering on this public key and collecting all transactions that are done with this specific key, the anonymity is not guaranteed, although there are specific mechanisms to ensure a higher level of anonymity. Another possibility to reveal the identity of a person is to deploy earmarked Bitcoins (or other units in a blockchain). See for an analysis of anonymity in the Bitcoin system: http://arxiv.org/pdf/1107.4524v2.pdf. (Last accessed on October 31., 2016).
In the case of a Land Registry blockchain it might not (always) be a good idea to guarantee a high level of anonymity (eg. in cases of fraud or terrorist activities).

6. The opportunities of Blockchain

The Because of the above mentioned features of blockchain technology, it might be possible to use the technology for other applications than crypto-currencies such as Bitcoin. For the *nodes* or the *ledger* it is irrelevant if a bitcoin is representing a value in USD or EUR. It is also possible to represent something completely different. Users can decide themselves for what units the Blockchain can be used.

It is known that the number of bitcoins is limited to twenty one million. Each bitcoin contains one million units (bits). Each *bit* is separately identifiable and programmable. That means every unit can be given specific properties. So, in theory it is possible to use the Blockchain technology for trading in Eurocents, in shares of companies, in Kilowatt of energy or votes for elections.

It is also possible to 'smarten' these specific units (e.g.: to employ the vote during elections for 2016 or to pay with the bits only for repaying tax debts). In such a case compliance will not be verified afterwards, but it will be programmed *in* the units and the system itself and therefore compliance can be checked in advance. It is also possible to program the units to automatically return to the issuing authority in case the unit is not used. One example could be sending back an unused vote during elections, in order to prevent misuse or incorrect counting.[24] Furthermore it is possible to use the technique for earmarking the money (e.g. in case a grant is awarded by the European Commission or in case taxes have to be paid). This can save a lot of overhead costs.

The programmable and open nature of Blockchain allows to rebuild or innovate the financial or administrative processes. Processes can be made more efficient and more transparent. A few examples[25] are:

1. Overstock. This American web-retailer tries to build a decentralised Stock exchange under the code name Medici,[26] using a P2P structure. It should build a technical layer on top of Blockchain, in order to have the possibility to issue and trade in shares of Overstock and other companies.
2. 'World Citizenship'.[27] With this experiment affordable decentralised passport services are created and investigated. This passport is meant to be used for identifying purposes between parties. Other parties are also working on *Blockchain-identification*.[28]

[24] Although, in theory – depending on the (political) system and its developers (in specific countries) – the voting ballot perhaps can also be programmed not to considered valid in case the vote has been used in favor of the opposing candidate.
[25] The following list is partly derived from an article by D. Reijerman on Tweakers.net, see: http://tweakers.net/reviews/3781/4/de-kracht-van-de-blockchain-nieuwe-toepassingen-van-de-blockchain-2-2.html. (Available in the Dutch language only. Last accessed on October 31., 2016).
[26] See: http://www.wired.com/2014/10/overstock-com-assembles-coders-build-bitcoin-like-stock-market/. (Last accessed on October 31., 2016).
[27] See: https://github.com/MrChrisJ/World-Citizenship. (Last accessed on October 31., 2016).
[28] See: https://onename.com & https://bitnation.com. (Last accessed on October 31., 2016).

3. Namecoin[29]. With Namecoin a Blockchain based decentralised registration and transfer system is introduced. This should lead to an alternative architecture for the Domain Name Structure of the Internet, (mostly) governed by multinational and governmental entities. Namecoin can be used for access of websites, using the .bit domain and store identity information.
4. Pegged Sidechains. With the introduction of *Sidechains* using the Blockstream[30] technology, new possibilities can be introduced and implemented without burdening the Blockchain technology too much. A Pegged Sidechain is a blockchain that validates data from other blockchains and enables bitcoins or other assets to be transferred between blockchains, fostering a new, open platform. These Pegged Sidechains[31] are separated from the central Blockchain, although it is possible to exchange data between the two.
5. Permacoin. This initiative is introducing a new scheme 'to achieve a more broadly useful goal: *distributed storage of archival data*'.[32] It requires clients to invest not just computational resources, but also storage for the public benefit (e.g.: data files of libraries).
6. Ethereum.[33] Ethereum is a[34] multi-purpose blockchain concept that offers a decentralised platform for developers to create applications that use the blockchain-technology. Its focus is to enable execution of smart contracts on a decentralized programmable open platform. It runs smart contracts: applications that operate exactly as programmed without any possibility of downtime, censorship, fraud or third party interference. It is meant for developing separate blockchains, based on a program language called Ethereum Script. By using Ethereum as a basis a digital artwork registry and marketplace (monograph), a trusted timestamp on top of Ethereum (Chronos), blockchain-chartered companies (Otonomos) and many other projects have started. Next to *smart contracts* Ethereum should enable financial applications, e.g.: opening a saving account, drafting a will and issuing shares. It is powered by a crypto-currency named Ether.

   Since there is no *single point of failure*, these applications should be very solid. As Ethereum promotes itself: *"Ethereum is how the Internet was supposed to work"*. The Ethereum product called *Frontier* helps developers to build software to store decentralised data. Yet, as we have seen during the DAO-hack[35], there might be a problem if there are no sufficient Governance

[29] See: http://namecoin.info/. (Last accessed on October 31., 2016).
[30] See: http://www.blockstream.com/. (Last accessed on October 31., 2016).
[31] Back, A., Corallo, M., Dashjr, L., Friedenbach, M., Maxwell, G, Miller, A., Poelstra, A., Timón, J. and Wuille, P., *Enabling Blockchain Innovations with Pegged Sidechains*, p. 5, (2014), https://blockstream.com/sidechains.pdf (Last accessed on October 31., 2016).
[32] See: http://cs.umd.edu/~amiller/permacoin.pdf. (Last accessed on October 31., 2016).
[33] See: https://www.ethereum.org/. (Last accessed on October 31., 2016).
[34] Other examples are Ripple and OpenLedger.
[35] See Chapter 7, paragraph a ("The fork in the Blockchain").

provisions in case of a shared ledger technology based system where transactions can be made without the use of a Trusted Third Party.

7. The possibility to use Blockchain for Land Registers

It is clear that the Blockchain technology is (probably) fit for various purposes as mentioned in the previous paragraph. The functionality of Blockchain can be described as a digital *ledger*. It serves the same functionalities as a sound Land Registry system: it knows who owns what at a certain time, it ensures single-ownership and it knows when a certain transaction took place. It is possible to 'track back' and therefore it should be possible to guarantee title.

Compared with a 'classic land registration system', blockchain may even provide some additional certainty. Because of the shared databases there is security of back-ups. Trust is added by cryptographic proof and a decentralised database, especially in the case the current administrator (Registrar) is not trusted. It might safe costs because of remediation of intermediaries (Notaries or licensed conveyancers) or administrators (Registrars). It therefore can be judged as an alternative for the classical Land Registers.

Because of its transaction dependency, in the Blockchain, it is not possible for a non-owner to transfer ownership. Checks on ownership using Blockchain technology are processed automatically, using transaction dependency and transaction rules, whereas in current Land Registry systems checks on ownership are executed by the Registrar, mostly by scrutinizing the deed and comparing this information to the content of the land register in person. That means that in the majority of cases the data of the seller mentioned in the deed is compared in person to the data of the current owner in the land register.

One of the exceptions[36] to this manual process is the computerized processing of deeds by using stylesheets, where the data with regard to the seller that is mentioned in the deed is automatically compared with the current owner as mentioned in the Land Register.

The only possibility for a non-owner to transfer ownership, using the Blockchain technology, could be the case where someone other than the owner uses the private key of the owner and uploads a transaction. However, there is a possibility for the owner to use a back-up system for his/her private pin-code in case of a crash of the used device (smartphone, tablet or computer). The *wallet* can be accessed by using a back-up that has previously been installed, although this back-up is executed by an intermediate. The often proclaimed risk that hackers can steal bitcoins, depends more on

[36] Or perhaps the only exception.

weaknesses with company security than the underlying core protocol itself. This in fact is no different than the DigiNotar-case as described in part I of this paper.

Furthermore the register is public and not to be changed since recording of the data is time-stamped and therefore indisputable. In current Land Registry systems this is applied by using time-stamps and audit trails. In case of the Land Registry system in the Netherlands, the moment the deed is received by the Registrar is decisive.[37] The deed will be registered, using the time the deed was received by the Registrar (priority). In theory it can happen that two deeds with regard to the same immovable property are received by the Registrar at the same time. In case this would happen, according to Dutch legislation[38], the time of execution of the deed is decisive. This time of execution is mentioned in the deed. In theory it could happen that two Notaries executed a deed with regard to the same object at the same time and sent is to the Registrar at the same time. Using the blockchain, one might think this is not possible. But in reality these situations happen quite a lot: a temporary situation of a so-called *fork* can occur in the Blockchain.

a. The fork in the blockchain

A *fork* is 'the situation where two chains exist with a shared genesis. These chains are identical up until the forking point, after which they exist exclusively in parallel (unless one is completely abandoned), creating two separate networks'.[39] As is explained in the technical paragraph of this chapter, Blockchain is a de-centralized network, which by definition means there is no absolute 'correct' chain. Each *node* in the network downloads all the blocks to connect to a chain. The *node* will ask for the most current block. In the case two *miners* both have been working on a new block have published their block, there is a 'race' going on between these two blocks. Both blocks intend to be the most actual block causing one of them being the invalid block. The 'race condition' is that both blocks are valid, because they both are based on the most recent block until the moment of mining. The race seems to be won by both blocks, but the real winner will be the one that reaches the most *nodes*. For that reason, it is important to reach as many *nodes* as possible, as fast as possible. These *nodes* calculate and conclude the block is valid. Both of these blocks are valid since they have all of the consensus rules, sufficient proof of work, but only one block can be valid. At this particular moment there are two versions of the blockchain, two competing versions of history. To explain the situation of the *fork* a bit further, it is useful to add, pure fictional, a different color to both competing blocks. The miner that receives a (red) block starts working on the next one as fast as possible. Once this new (red) block had been created (*mined*), the new (red) block will be published as well. The other

[37] Vos, J (2012) & Vos, J (2013).
[38] Article 21 of book 3 of the Dutch Civil Code (art. 3:21 BW).
[39] See: http://blog.cex.io/bitcoin-dictionary/what-is-bitcoin-fork-14622. (Last accessed on October 31., 2016).

nodes will now check this new (red) block and will come to the conclusion that this block is the (red) successor of the previous (red) one.

The *nodes* that approved the new (blue) block will also ask for the newest block and find out that the newest block in fact is the (red) successor on the (red) block. They then come to the conclusion that the (blue) block is invalid since this chain is one block shorter and will continue their validation on the red block and its successors. The longest chain has won and the block that did not have a successor yet is malicious and will be deleted.

A *fork* happens every day on average. A *fork* on a *fork* also happens every now and then. In April 2013 a new version[40] of bitcoin was released, causing a twenty-six-block *fork*.

One of the most, or perhaps the most well-know fork situation has been the fork that was created during the DAO-hack.[41] Because of this hack the equivalent of over 60 million US Dollars (in Ether, the cryptocurrency that is used on Ethereum) were lost. The perpetrator of the hack spotted a loophole[42] in the Dao`s "smart contract" and made use of it.

b. Land Registry principles

Twaroch and Muggenhuber[43] point out that a Land Registry system is successful when all partners involved (owners, banks, Notaries, et cetera) have trust in this system. This is independent from legal and technical solutions. For having trust a third dimension the organisational or institutional aspects of the system have to be taken into account.

In some (developing) countries people do not always trust the current system. In some cases there is fraud and corruption and in other cases there is a lack of quality. A blockchain-based Land Registry system may seem to bring a solution for these problems, although in reality it does not. The real challenge for these countries will probably be the initial identification of right holders and the creation of actual titles. Once it is known who is the actual owner of a certain parcel, the ownership of the parcel can be transferred. This initial phase will not be realised by using blockchain. Blockchain is designed as a '*shared single source of trust*', to exclude (mistrusted) governmental parties and banks, but it demands an empty stage which everyone can agree on as a starting point. This Genesis block

[40] There were two types of databases, used for mining. One of these two types had a bug that could not be triggered. Since the new version of bitcoin a block could now consist of more than 1025 transactions. This crashed the Database. Once rebooted, the database asked for the most recent block, which consisted of 1200 transactions. Because the database could not cope blocks > 1025 transactions, it crashed again and started re-booting again. By organising an emergency summit overnight, the next morning all hashing power was used to shift back. A twenty seven block chain was built and with that block the twenty six block-fork-situation was invalidated.

[41] See: http://www.forbes.com/sites/francescoppola/2016/06/20/the-dao-hacking-shows-that-coders-are-not-infallible/#33a8791c125d (Last accessed on October 31., 2016).

[42] A description of the DAO-hack can be found here: http://hackingdistributed.com/2016/06/18/analysis-of-the-dao-exploit/ (Last accessed on October 31., 2016).

[43] Twaroch, Ch. and Muggenhuber, G. (1997). Evolution of Land Registration and Cadastre; Case study: Austria, In: Lecture material Workshop F, JEC GI, Vienna p. F.3 - F.16 (p.5).

will be the problem in the case of these countries, because there is no trust and so there will be no consent by all interested parties. In those cases a blockchain-based Land Registry will not work.

The principles of Land Registration are often[44] [45] divided into four:

1. Speciality principle: the concerned object ((immovable right regarding an) immovable property) and subject (the person (also the person behind the legal entity) must be unambiguously identified in Land Registration and consequently in the documents that are submitted for registration.

   In the blockchain the identification of a person is rather difficult. The technology was built *not* to share these data with the participants in the blockchain[46].

2. Booking principle: until the change or the expected right is booked or registered in the Land register, the change in real rights on an immovable property is not legally effectuated.

   The blockchain logs all validated transactions in a sequence. This means the system is fit for checks on ownership, titleholders and so on. This means blockchain can be in accordance with this principle. It is a matter of filling the empty first stage with assumptions which everybody can agree on.

3. Consent principle. This principle implies that the real entitled person who is booked as such in the Land Register must give his consent for a change of the inscription in the Land Register.

   This principle is met, since the owner of the asset has to sign the transaction in the blockchain, before it is uploaded to the network and put in a block.

4. Principle of publicity: the Land Registers are open for public inspection. Furthermore there is third party protection, for third parties in good faith.

   A blockchain is a shared database that logs all validated transactions in a sequence. It is a public register that is not to be changed and therefore indisputable. It is a '*shared single point of truth*', trusted by the users, but there is no third party protection.

Furthermore there is the division of principles related to the registration of (Anglo-Saxon) titles. These three fundamental principles, identified by former chief land registrar, Theodore Ruoff[47] are:

[44] Kurandt, F. (1957). Grundbuch und Liegenschaftskataster [Land book and parcel cadastre], Sammlung Wichmann, Band 18, Berlin: Herbert Wichmann Verlag (German)
[45] Henssen, Jo (1995). Basic principles of the main cadastral systems in the world, In: Modern Cadastres and Cadastral Innovations, Proceedings of the One Day Seminar in Delft on May 16, 1995, FIG Commission 7 and University of Melbourne, p. 5-12
[46] See: footnote 23.

1. the *mirror principle*. It states that the register of title is a mirror that reflects completely and accurately the current facts pertaining to the title. It reflects ownership and requires all rights to be registered. Although, in Land Registries sometimes there is a 'crack in the mirror' because of certain third-party rights (or 'overriding interests') that may affect a piece of land even though they are not registered and because in some cases unenforceable or obsolete rights continue to be registered.

   Not registered legal facts, affecting the immovable property, is not only the case in Torren`s based systems. It is also the case in the Netherlands, where it is not mandatory to register cases of prescription. This means that the owner mentioned in the cadastre registration is not always the real and current owner. The same applies to the registration of a certificate of inheritance. From a Dutch Land Registry perspective it is because of these shortcomings that it will be very difficult to complete the first block (Genesis block) to present a current and actual situation.

2. The *curtain principle*, which means that the buyer can rely on the content of the registers. The purchaser (and anyone else drawing information from the land register) does not need to assure himself whether there are specific elements that are not shown. He or she does not need to investigate trusts and equities or search behind the title as depicted on the register.
   Since blockchain is using *accounts* instead of complete identification of (natural and legal) persons, the curtain principle is respected by the technology. Yet, this can also be mentioned as one of the biggest risks of this disruptive technology (for some legal systems): who is the owner of the plot, once it is part of the blockchain-based Land Register? In the Netherlands, the Notary has to identify and include all parties involved in the deed. The deed itself is registered, so all parties will be mentioned, unless a trust or some other (foreign) legal entities is involved. In those cases the Ultimate Beneficial Owner is not mentioned and known. It is proven that many criminals have been using these legal entities for laundering there money and buying property in the Netherlands and elsewhere.[48] By using the blockchain technology the identity of parties can be hidden. Of course, there is the possibility to amend the system and demand publication (or the use of electronic) ID`s. Another possibility could be the use of a side-chain concerning blockchain-identification.
   In the Netherlands up until today one cannot completely rely on the information that is mentioned in the cadastre registration, although from an administrative point of view governmental parties have to rely on the cadastre registration and do not have to look into the

[47] Ruoff, T.B.F (1957), *An Englishman Looks at the Torrens System*, Law Book Co of Australia, 1957, p.8.
[48] Koningsveld, van T.J. (2016), *De offshore wereld ontmaskerd (*"The offshore world revealed"), 2016.

Land Register any longer.[49] From a civil law point of view, one has to scrutinize the deed lying underneath the information that is currently mentioned in the cadastre registration. This means that using the blockchain technology would not improve the legal certainty at once. Filling the first block in the blockchain would be done with the current information and for that reason this blockchain would not provide title: what is registered in the system, will be part of the system without any change. That would mean that the Dutch Land Registry system would remain a deeds system. For that matter, next to the previous titles, the current deed should be amended to the first block so everyone can check ownership. From a technical point of view, the legal system could easily be changed to a title system: after the creation of this (Genesis) block, amending deeds to the changes would no longer be necessary. The Blockchain system relates every block to the previous one, so it is certain that the new owner obtained the land registry object from the previous owner. Legislation would have to be amended in a way that one may rely on the approved blocks (titles) in the chain. It would no longer be necessary to scrutinize all the previous titles (deeds) for defects with regard to ownership. The checks would have to be done once (Genesis block) and from that point on, the blockchain system, possibly combined with the use of the data derived from the various key registers would have to provide all checks that are currently done by Notaries and Registrars.

3. the *insurance principle*. Anyone who suffers loss because of a wrong reflection of the title through human frailty, must be put in the same position, so far as money can do it, as if the reflection were a true one. In other words, the accuracy of the register is guaranteed and any person who suffers loss as the result of the inaccuracy is indemnified.

   This is different in the Netherlands, because of the ‘modernised‘ deeds system (or: semi title system). In case the wrong person is mentioned in the deed, the Notary who drafted the deed will of course be liable for this mistake. Kadaster is only liable when a mistake has been made while wrongfully updating the cadastre registration with information from the deed.

   In case of the use of the blockchain technique, the liability is uncertain or perhaps can be described as diffuse. In the (theoretical) case a mistake has been made in the computing process (e.g. a source code failure), the IT specialists who created the blockchain night be liable[50] for this mistake. Challenges still exist to implementing this technology. There are still some scalability limitations and requiring updates for the core code of blockchain are proving

[49] Since 2008 the Cadastre registration is part of the system of Key Registers, which means that all governmental organisations have to rely on the cadastre (and do not need to check the Land Register, in case of administrative business). See: Vos, J (2014).

[50] It is questionable whether this will be the case in all situations. First of all the system runs on open source software. Many people have contributed to its development and updating, so who is to be held responsible? Second, there is no mandatory use for the software.

highly contentious among developers. If the blockchain technology would be implemented by Kadaster for its own registration activities and processes, it will be Kadaster who is liable in case something would go wrong. Because of the semi-title system the implementation would not involve any additional liability. The Notary would still remain liable for the content of the deed and therefore for damages caused by defects in the deed itself. In case Kadaster would ask the notaries to use the blockchain technology, it would be wise to use disclaimers and/or terms of use, although in case blockchain is the prescribed method to be used, these disclaimers and terms of use are perhaps to be nullified. To pay any damage that may occur, it might be useful to require payments of fees from participants. Part if these payments go to the purchase of cyber insurance to cover the participants for risk of loss. A possible other solution might be to require that each participant purchases certain insurance for itself and absolve all other participants of liability. Somehow an indemnity has to be paid for any loss. The answer to the question who would have to pay for the damages that may occur, depends on the way the blockchain would be implemented.

c. *Governance of blockchain in Land Registry matters*

If it would be decided that the blockchain would be the best solution to keep a Land Register system, there are various questions that should be answered with regard to governance of such a system. The first question is *who* would have to design and keep the Land Registry blockchain. Can this be done by the community? Or by an institute such as Kadaster? The next question would be whether this blockchain should be kept in a private, public or a hybrid format.

In case of a public Land Register blockchain, everyone can join the blockchain and use the software. It is the most reliable application of the blockchain technology because of the security offered by the use of a large number of *nodes.* Because of its globally accessible public ledger the information stored on the blockchain cannot be deleted or manipulated by any person.

Private blockchain

In case of a private Land Register Blockchain, one entity (Kadaster?) uses the blockchain technology to record transactions, overriding the underlying principle of blockchain of the creation of distributed trust by using shared databases. On the other hand, because of the poor number of *nodes*, the validation rules can be adjusted easily. Since being the only entity using the technology, consensus is met in an instance. This makes the system very flexible.

In case of a *private blockchain*, there is no *full* public and controlled network that is state machine secured by crypto economics (eg. Proof of work, Proof of stake).[51] It is possible to create a system with more tightly controlled access permissions, modification rights and permission to read (certain elements). In the case of a private blockchain, writing permissions are kept centralized to one organisation (Kadaster). Reading permissions can be restricted or public. Since the Land Registers are completely open[52] and available, in the case of the Netherlands read permissions would not need to be implemented.

One of the advantages of a private blockchain is the possibility to change the rules of a blockchain or to reverse a transaction. This could be the case when a Court ruling would mean ownership has to be re-transferred[53] or in case apartment rights do no longer exist (and the plot itself has to 'revive' from an administrative point of view).[54]

The implementation of a private blockchain within Kadaster for the purposes of keeping the Land Register does not seem to have any added value. A new way of registration would have to be designed and implemented. Furthermore substantial computing power to *mine* has to be installed, especially with regard to the number of transactions that has to be uploaded and verified on a daily basis. Next to that, there is the same risk of being hacked as in a traditional system. Comparing the transactions with a public blockchain, transactions are cheaper in a private blockchain since they only need to be verified by a few nodes that can be trusted. It is not certain these costs are lower than the computing costs of a traditional Land Registry system. The only added value is the degree of cryptographic auditability, although this can also be implemented in another way (eg. A well-functioning audit trail, the use of a *four eye principle* during the registration process as well as quality verification after finishing registration). A well-functioning Land Registry system consists of a system of checks & balances. In most cases Registrars are checking the documents they receive from (licensed) conveyancers (eg. Notaries) and these conveyancers are checking the content of the Land Registers after updating. In fact, in the Netherlands, the Notary is obliged[55] to check the Land Registers at three stages during the e-conveyancing process[56], so (s)he knows for sure the deed has been processed in accordance with the content.

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[51] Buterin, V., *On Public and Private Blockchains*, (blog), https://blog.ethereum.org/2015/08/07/on-public-and-private-blockchains/ (Last accessed on October 31., 2016).

[52] Kloek-Tromp, I.J., *The Dutch Land Registry as a Producer of Data*, (paper at this IPRA-CINDER conference).

[53] Although this can also be realized by recording the court ruling. This way, both the (defective) deed of transfer and the court ruling are registered and history is preserved, the way it should be.

[54] In the Netherlands splitting a parcel or a building into apartment rights, does mean that – from an administrative point of view – the parcel will disappear and be replaced by apartment rights. Once the apartment rights disappear (by abolishing the separate building entities or unify the pieces of plot to the plot that was once split into apartment rights) the parcel will revive.

[55] In case the Notary does not check the Land Register (s)he will be liable. In a recent Court case the candidate-notary got a disciplinary warning from the disciplinary Court. See: ECLI:NL:TNORDHA:2 (available in the Dutch language).

[56] Vos, J (2012) & Vos, J (2013).

Public blockchain

In case the Land Registry system would be replaced by a *public blockchain* anyone in the world can read the content of the blockchain. This is in accordance with the current situation in the Netherlands with regard to the (content of the) Land Registers, but it would not always match various other Land Registry systems. There are possibilities to have not all information (all contracts or deeds) available for everybody in the world. It is possible to create reading rights for specific parties. Furthermore it is possible to use privately administered smart contracts on public blockchains. There is also the possibility to create cross-chain exchange layers between public and private blockchains. By using these combinations different kinds of hybrid combinations can be realised.

In a public blockchain anyone in the world can participate in the consensus process. It is possible to contribute to determine what blocks (and therefore which transactions) get added to the chain. The current status of (ownership of) a certain plot of land is therefore a matter of the public. The strength of the public blockchain is the impossibility for the developers to make changes to the chain itself. This gives a certain level of trust to the users of the blockchain. A lack of policies supporting equitable rights for all, high costs to formalize properties, inefficient bureaucracies taking years to accomplish rudimentary tasks and general issues with poor governance can be reasons to conduct research on the feasibility of blockchain for the creation of a Land Registry system.[57] It is questionable whether these modern techniques will actually help creating a reliable Land Registry system. It seems very tempting to use blockchain technology in (less developed) countries where there might be fraudulent governmental parties, perhaps also conveyancers (notaries), surveyors and registrars. And of course it is possible to upload every transaction or first entry, once created, directly into the blockchain. But the real challenge on these countries seems to be the initial identification of right holders, the details regarding their rights, restrictions and responsibilities.[58] Furthermore, ascertaining and documenting the geographical boundaries has to be realised in many cases. For these purposes many other possible solutions may be more suitable. Most of the time Land Registration systems in less developed countries should be cheap, fast and designed to meet the people`s needs (‘Fit for purpose’ approach).

Blockchain technology cannot offer a solution for the deep political failings and corruption, but by starting to record each phase (survey, define and draft titles) in the blockchain, it could help. Once the title itself is registered, verifiable ownership is realised. As already mentioned, this can also be done by using different techniques, depending on the circumstances.[59]

[57] https://www.devex.com/news/bitcoin-technology-for-land-administration-86362 (Last accessed on October 31., 2016).
[58] See footnote 57.
[59] In countries where there CPU and electricity are not constantly available for everybody, the use of blockchain does not seem to be the best solution.

Hybrid blockchain

When using a hybrid Land Register Blockchain, a limited number of entities or persons is part of the blockchain. At this stage, Banks seem to be investing in a hybrid version of Blockchain technology where groups of banks will upload transactions to the chain to settle interpayment banking services. The same could perhaps work for the chain of transfer of ownership: licensed conveyancers or Notaries will work together with Registrars in a Land Register Blockchain. This could mean that a Notary or licensed conveyancer will upload a transaction and the Registrar will approve this (in his role of *miner*). After the mining is finished and the transaction is approved, the transaction is complete. As in the private Land Register Blockchain the principle of distributed trust may be frustrated, since the Blockchain is not open for everyone. Apart from that, the *miners* (Notaries and licensed conveyancers) may form an identifiable set and therefore can have discretion over the rules determining transaction validity. In such a case all participants have to implement and execute the new rules in exactly the same way.

When the current Land Registry system would be replaced by using a *hybrid* blockchain, used by the current stakeholders in the chain of real estate transfer, there could be a role for both the Registrar and the Notaries, bailiffs and/or other parties who are sending official documents to be recorded in the Land Register. The role of these stakeholders is to be considered. It could indicate that (licensed) conveyancers check the ID of the persons involved and provide them with an electronic identity by which they can upload a transaction (transfer of ownership, a mortgage deed or a seizure) themselves. In such a case the role of the conveyancers is reduced from a legal professional scrutinizing all kinds of information and drafting a deed, seizure or other official document to a professional who is issuing e-ID`s. In such a case the Registrar would have to rely on the capacities and skills of the parties involved who are uploading the transaction themselves.

Another possibility could be the situation where the conveyancers are uploading the transactions to the blockchain and the Registrar`s *node*(s) will approve (the transactions in) the block.

A third possibility would be the situation where the conveyancers together with the Registrars would create a consortium that runs the blockchain. The conveyancers would upload the transactions and, together with the registrar, could be the validators. Each of them could operate as a node and a specific number of nodes must sign every block in order for the block to be valid. The risk of a 51% attack arising from some miner collusion does not apply in this case, since all validators are known, unless the current network of Notaries (and Registrars) would be threatened and their computers would be taken over by a hacking entity or they would somehow be prevented from seeing the actual longest chain. The less nodes are needed, the more risks can occur. It is possible to change a block when substantially more computing power can be used. All that has to be done is to compete by creating a longer chain than the current longest one. In case of the blockchain concerning bitcoins one has to

build a chain with more than 436.739 [60] blocks (or as much as there are today) in ten minutes (before the other chain will be one block longer).

In theory, an alliance of conveyancers could decide to give effect to another transaction by creating the longest chain. The right to read the blockchain can be public, depending on the legal system. In the Netherlands this blockchain would be publicly accessible, since the Land registers are open for everyone.

Again, as is the case with a *private blockchain*, transaction costs may be lower compared to a public blockchain, since less nodes are needed to verify the various transactions. These transaction costs may change in the long term with scalable blockchain technology that promises to bring back the costs of public blockchain.

Furthermore there is a possibility to quickly intervene manually, allowing the use of consensus algorithms which offer finality after much shorter block times. As is the case with public blockchains, the question is how the Notaries and/or other (licensed) conveyancers will be rewarded for their 'approval services'. In the bitcoin blockchain the *miners* are rewarded by mining some bitcoins in each block. But with regard to a blockchain where *rights in rem* concerning Land registry objects are transferred, the miners cannot be rewarded by mining[61] *rights in rem* or Land Registry objects (eg. square meters).

In all cases (private, public or hybrid blockchain) it is not guaranteed the system is completely democratic.[62]

d. Diversity in Land Registry

To introduce a Land Registry blockchain in a country with a well-developed Land Registry system, it seems necessary to know and incorporate all existing *rights in rem* and all existing Land Registry objects in the first block, the Genesis block. If not all rights in rem and objects are incorporated in the system, there is no possibility to represent the actual situation with regard to the objects and *rights in rem* concerning all immovable objects. Of course there is the possibility to divide the content of the

[60] Actual number of blocks at the time of drafting this paper. Source: http://bitcoinclock.com (Last accessed on October 31., 2016).

[61] The role of block rewards and transaction fees play in providing the resilience of the Bitcoin blockchain and other payment methods are examined in a white paper, published at: http://bitfury.com/white-papers-research. (Last accessed on October 31., 2016).

[62] This even seems to be the case in a public blockchain, where everyone use the same ledger (and software). Despite the public use, the *miners* are running the show, since they have the computational power and can invst in the newest equipment to *mine* the blocks.

Land Registers into smaller units on a geographical basis (eg. Villages and cities[63]), on the basis of the various rights in rem[64] or any other way of division (eg. cables and pipelines in the soil or apartment rights or condominium). Depending on the way the content of the Land registers is divided, each (sub)division perhaps could (or even: should) be put in a new blockchain, some kind of a sidechain to the 'parent chain'. The parent chain could deal with (information regarding) transfer of ownership of a Land Registry object, where sidechains could be used for realising apartment rights or for the transfer of other *rights in rem*. In a sidechain it is possible to transfer an asset from the (original) parent chain to a sidechain, possibly onward to another sidechain, and eventually back to the parent chain, preserving the original asset.[65] In Bitcoin terms: a bitcoin (in a sidechain) would remain a bitcoin (as derived from the parent chain), since any coin moved from Bitcoin could be moved back. Sidechains are able to support their own asset (eg. 'Eurocoin').

The use of sidechains would make it possible to divide a parcel (parent chain) into a set of apartment rights (sidechain). It would also make it possible to move back the object in the sidechain (apartment right) to the 'parent chain' (parcel), as an apartment building may be restructured or a usufruct or lease may end under specific circumstances (eg. death or passing of a period of time). The parcel (parent chain) cannot be changed or sold, since it is being preserved. It is 'locked'. This also seems very useable in Land Registry matters, since a building cannot be divided into apartment rights in case it already has been divided into apartment rights. If one or more of the existing apartment rights should be subdivided into new apartments, there should be created a new sidechain with regard to the original apartment right(s) that now will be subdivided.

In a country where there is no *numerus clausus*, the introduction of a Land registry blockchain might even be more complex. In such a system new *rights in rem* can be created. Those specific rights should then perhaps be put in another sidechain. Another possibility might be the possibility to smarten specific units within the blockchain.

e. Providing actual and easy to understand information

Actual information

There should be consensus (in some way) about the content of the Genesis block. This means that, in case of a public Land Registry blockchain used by everyone (and not solely by Registrars and other professional parties), there should be consensus on the current situation. With regard to filling the

[63] As is the case in Honduras, where it is (or was) planned to begin recording land title records on the blockchain by organizing a proof of concept for La Ceiba, the fourth largest city in Honduras. The most actual status is presented at http://www.coindesk.com/debate-factom-land-title-honduras/ (Last accessed on October 31., 2016).

[64] Although the division on the basis of the various rights in rem does not seem to be suitable, since it should be possible to divide ownership in 'bare ownership' and usufruct, a building right, a lease or any other existing right in rem.

[65] Back, A. (et al) (2014), p.6.

Genesis block, existing and well-functioning title systems and Torren`s based Land registry systems would perhaps seem to be more fit for using the blockchain technology. In case (such) a Land Registry system is not complete – in many countries there are still first entries to be made – the blockchain might perhaps be less suitable. In those cases it can only be used for the registered parts of the parcels and objects. What isn`t registered, cannot be put in the Genesis block.

There is a risk of presenting information that does not represent the actual information. This can be the case during the *mining*-process as explained in chapter five. This process may take up to ten minutes. A more time-consuming uncertain period of time is the situation of a *fork* as explained in chapter seven. In such a case there is uncertainty about the title-holder, since there seem to be multiple title-holders at the same time, until the fork-situation is solved. In a 'classical' well-functioning Land Registry system there is certainty after the document has been received and the time-stamp has been placed. In case of the use of a sidechain, there are two more waiting periods:

1. The confirmation period: the period an asset (parcel) must be locked on the parent chain before it can be transferred to a sidechain. This period can take up to one or two days. After this period the transaction on the sidechain can be created.
2. The contest period: the period of time in which a newly-transferred asset may not be spent on the sidechain (to prevent double spending). Also this period can take up to one of two days.

During these waiting periods, the assets are locked at the other chain (parent chain or vice versa, the sidechain). This would block the conveying immovable assets for a certain period of time, while in a 'classical' Real Estate system the deeds are received and traceable, if not published straight immediately. For that reason in most Land registry systems it is possible to transfer multiple times in a short period of time, being able to investigate the actual (legal) situation.

Once the information is put on the blockchain, it is part of the (public) information. Besides the question if people can rely on the (legal sustainability of the) information, it is not certain if and how the actual and current situation with regard to the owner, the (various) right(s) with regard to the object can be presented. Or will it be just the chain of titles that is visible? In other words, data retrieval is a topic that is not yet put into practice. A current Land Registry system will show – despite complexity of connections between Objects, Rights and Person – the actual (legal) situation with regard to these three items. Will this be proven possible within a Land Registry system that is based on Blockchain technology as well?

f. Blockchain will not change a legal system

A Land Registry system cannot be changed from a deeds to a title or Torren`s system or vice versa by introducing a blockchain-based Land Register. It will not bring any changes in any system. What goes in, will come out. In case blockchain will be used in a deeds system, there will still not be issued any title by the Registrar. In case of a title system the title will be transferred by using blockchain; the title will not get lost.

Blockchain technology will not improve legal certainty with regard to the content and legal meaning of the first block. In a case where there is uncertainty with regard to the title holder,[66] blockchain will not bring any changes. Improvement of the quality and the completeness of the Land Registers can be realised by recording new transactions and/or – depending on the legal system – titles in the subsequent blocks or by uploading new transactions in the first block. This is similar to a 'classic Land Registry system': by recording new deeds or transactions, the Land Registers become more accurate and give an actual overview of the current state of play.

There are possibilities to mislead or circumvent (parts of) the blockchain system in certain cases. It is possible to create incremental transactions, where two parties agreed on (multiple) small transactions *off-blockchain* and finally recording only one all-embracing transaction. This may save time and capacity in the blockchain *and* it does save cost, as for every transaction the *miner* receives a fee. The only precondition is the fact that the parties involved have to trust each other.

Finally it is important to decide what will be stored on the blockchain. Will it be the data of the actual transaction (as is the case in a title system)? Or will it be the complete contract (as is the case in a deeds system, where deeds can be retrieved and scrutinized by everybody who wants to see the full content of the transaction)? Because of a maximum size of a block, it seems impossible to upload the original contacts on the blockchain at this moment. This can be solved by putting the *hash* value of the deed (or a so-called 'pointer') which refers to the original contract on the blockchain. The disadvantage of this approach is the need to store the corresponding deed somewhere safe (on a (traditional) server). Although the content of the deed is irrefutable because of the hash value, there is still the (same) risk of losing the document, as can be the case in a traditional Land registry system.

g. Preconditions and exotic transactions

[66] eg. prescription cases that are not registered, disputes on boundaries and deceased persons where the heirs did not register a certificate of inheritance.

In many cases there are preconditions that are of importance in the process of the transfer of ownership. It could be the spouse or co-owner who has to give consent to the selling of the marital property[67], the dissolving condition of funding or any other precondition parties agreed upon (transferring ownership, free of mortgages, seizures and other burdens). In a 'classic Land Registry system' it is the task of (both) the licensed conveyancer/ Notary (and/) or the Registrar to check whether the preconditions have been elaborated or not. In a blockchain system this scrutinizing of the deed will not take place by a person. It has to be done by the system itself. For this, it is possible to make use of a *smart contracts* infrastructure. Smart contracts are computer protocols that facilitate, verify or enforce the negotiation or performance of a contract, or that obviate the need for a contractual clause. [68] Within this infrastructure 'each *node* acts as a title registry and escrow, executing changes of ownership and automatically checkable rules governing those transactions, and checks the same work of other nodes'[69]. The code is the contract or code is law. Amongst else, replicated contract execution is implemented in Ethereum. There are centralised escrow intermediates and Distributed autonomous Companies or Corporations (DAC`s) that can do the same, although the fees are relatively high (three to six percent (3-6%)). The precondition to use these escrow services is the existence of a currency in the same blockchain, so the intermediate can be paid, or perform a cross-chain[70] transaction by using a private chain that can be verified by a public chain. As we have seen during the DAO-hack, a flaw in the contract can cause a lot of (legal) uncertainty, especially when there is no Trusted Third Party involved who is entitled to resolve the dispute.
The DAO on the Ethereum platform has learned that there is a need for good Governance provisions in case of a shared ledger technology based system where transactions can be made without the use of a Trusted Third Party.

By using so-called stylesheets in the Dutch Land Registry system (since 2008), scrutinizing of the deeds, fulfilling the checks and requirements for registration purposes and to a certain extent checking on meeting specific conditions is done in a different kind of way, but with the same result. One might say that these stylesheets are also smart contracts (the code, with certain preconditions, to transfer ownership).

[67] As is the case in the Netherlands, resp. article 88 of book 1 of the Dutch Civil Code (art. 1:88 BW) and in some specific cases article 175 of book 3 of the Dutch Civil Code (3:175 BW).
[68] https://en.wikipedia.org/wiki/Smart_contract (Last accessed on October 31., 2016).
[69] See footnote 59.
[70] One good example is https://github.com/ethereum/btcrelay (Last accessed on October 31., 2016)., which is an Ethereum contract for Bitcoin. Amongst other services, it optionally relays the bitcoin transaction to any Ethereum contract.

8. Conclusions

Looking at Blockchain technology, many of the Principles of Good Governance in Land Administration can or will be met. The elements of transparency and efficiency as well as the history of transactions (chain of title) is present. Furthermore the unique identifiers (parcel numbers, identification numbers of (legal and natural) persons) can be stored. As transaction rules can be implemented, the validity of transactions can be checked. In current well-functioning Land Registry systems this is mostly executed by hand, by scrutinizing the deed. In some cases this can be done by computers, as is the case in stylesheet-based deeds in the Netherlands. The business rules incorporated in the stylesheet can be relatively similar to the transaction rules in the smart contract that can be used in the blockchain technology.

Therefore, one may conclude that in case a Registrar is planning to introduce automated processing of deeds, blockchain perhaps could be one of the possibilities. To ensure this is possible, further research is needed.

The introduction of standardised texts and clauses, combined with stylesheets, is a proven technique, although there some pitfalls exist and points of attention need to be taken into account.

In case of the implementation of a blockchain-based Land Registry system, one should not underestimate the complexity of the legal system, the meaning of the *rights in rem* (*numerus clausus* or not), the complexity and variety of different transactions and the proceedings of the legal professionals in the chain of conveying immovable property.

This complexity would even grow when a cross-border Land registry blockchain would be introduced. In such a case there should be an empty state which everyone can agree on. This empty stage would mean the objects are known and registered, the various rights in rem[71] are known and registered and there is an agreement on (differences between) common law and civil law principles and causal and abstract systems. At this moment it is not sure whether all preconditions can be met. One of the possible risks is the transaction speed, especially since in the current Dutch Land Registry situation a deed of transfer can be processed completely automatically, without the interference of a human, in tenths of a second.

Sometimes technicians and other enthusiastic decision makers[72] express their opinion that modern techniques can replace legal professionals quite easily. Without the cooperation of legal professionals,

[71] As is experienced during the IMOLA project (see this paper, part I) it seems possible to realize a European Land Registry Document. This document will consist of a common structure for Land Registry information, accompanied with a thesaurus, certain placeholders and factsheets. With this information one could compare rights in rem to a certain level and know what is the true meaning of a foreign right in rem.

[72] The Minister of Finance of the Netherlands stated in an interview Notaries could possibly be replaced by the use of blockchain technology which perhaps could be more easy and a lot cheaper. See:

who indicate the legal meaning and its implications, these techniques will not be applicable in the right way. Implementation of such techniques would result in pure chaos[73].

To implement the blockchain technique, one does need the legal expertise of the experts in the field of (electronic) conveyancing. For drafting deeds this is the (licensed) conveyancer or the Notary, for updating the Land Register this is the Registrar. As I mentioned at the Cinder congress in 2012 in Amsterdam, lawyers should make use of modern techniques and have to become more inventive solution thinkers.[74]

To ensure legal knowledge in future, for lawyers, also the lawyers from the 'classic generation', it is time to shake hands with the 'disruptive generation', a generation creating new technical solutions for different purposes. Whether legal proceedings and checks are executed by a computerised system or by hand, it is important that liability is covered. Furthermore it is important that someone is able to solve the problems that occur in case something might go wrong. The role of lawyers is not expected to be (completely) replaced by these disruptive technologies. People rely on technique, but want to revert to a lawyer in case of problems. In my opinion, Lawyers should be facilitated by modern techniques and computerized systems. Unlike Lessig[75] I believe algorithms are no legislative measures. Yet, they can sure be of great help and simplify or fasten certain procedures. New (disruptive) techniques can be of (great) help in many cases, as long as it does not compromise the principle of checks and balances.

Once the role of the laywer is ignored, circumvented or neglected, the use of new technology (in Land Registry cases) will be truly disruptive. Legal expertise and a system of checks and balances is needed, as we have seen during the DAO hack. Although lawyers should make use of modern techniques and have to become more inventive solution thinkers[76], it is clear that Land Registers are too important to be replaced by a technique that does not seem to be suitable or does not fit the needs of the public (yet).

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www.rtlnieuws.nl/economie/home/dijsselbloem-niet-erg-als-banken-marktaandeel-inleveren-door-fintech (Available in the Dutch language only. Last accessed on October 31., 2016).

[73] According to the Erasmus Innovation Monitor only twenty-five percent of all innovative successes is extracted from technology. Seventy-five percent is extracted from the style of leadership and the organizing methodology. See: http://www.eur.nl/fileadmin/ASSETS/press/2015/November/Erasmus_Innovatiemonitor_2015_onderzoeksrapport.pdf (Available in the Dutch language only. Last accessed on October 31., 2016).

[74] Louwman, W. and Vos, J. Electronic & Cross-border conveyancing techniques - Cutting edge law practices, in: XVIII Congreso Internacional de Derecho Registral IPRA-CINDER | 18th *IPRA-CINDER International Land Registration Congress Amsterdam 2012*, Tirant lo Blanch, Valencia, 2016, p. 409.

[75] Lessig, L. (2006), *Code: Version 2.0*, New York, Basic Books, 2006.

[76] Louwman, W. and Vos, J. (2016)