Universität Zürich[UZH]

Thesis

for the attainment of a

Master of Advanced Studies in Real Estate

A use case of blockchain technology in the real estate industry for the rental agreement and accessory charge settlement processes

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List of abbreviations

Art.	Article
BTC	Bitcoin
CEO	Chief Executive Officer
CHF	Swiss Franc
CIO	Chief Information Officer
EGID	Federal building identification number
EWID	Federal apartment identification number
EWZ	Power station
IT	Information technology
OR	Obligationenrecht – Swiss Code of Obligation
P2P	Peer-to-peer
PoS	Proof-of-Stake consensus mechanism
PoW	Proof-of-Work consensus mechanism
REM	Real estate management system
SHA	Secure hashing algorithm
ZertES	Swiss Federal law regarding electronic signatures

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Executive Summary

This thesis aims at identifying a use case for blockchain technology in the real estate industry, in particular in the processes of a property management company in Switzerland with a focus on rental apartments. Using a case study approach and theoretical concepts of business model innovation, the Business Model Canvas for a property management company was developed, identifying the key activities that could be made more efficient. The two processes which seem to have the largest potential of being put in a blockchain environment are the rental agreement and accessory charge settlement processes. A use case for blockchain technology for these two processes is developed, outlining the major criteria that a blockchain should fulfil. With the help of expert interviews, the developed use cases were analysed for feasibility and a potential implementation. Resulting from the interviews, experts do see potential in the development of both use cases. The main concern for the rental agreement process is that the online approval of the tenants would not count as an official signature in a court of law. However, due to the form-free nature of rental agreements in Switzerland, this should not pose an implementation issue. For the accessory charge settlement process, experts see large potential. The interdependencies from third party providers and that there is no clear guideline regarding which costs can be passed on to the tenant presents a limitation to the proposed use case. Before such guidelines exist, it will hardly be possible to enter an allocation key into a blockchain system, as this would work exactly as programmed.

Both processes would make the current processes more efficient, transparent and traceable. However, due to the theoretical nature of the developed use cases, a potential implementation would need to be tested and verified by experts. As a future outlook, the full integration in a blockchain of the on-boarding and off-boarding process of tenants, from tenant selection until moving out, including rental adjustments could be analysed. For this however, the current laws will need to be reviewed and adapted, as the cancellation of the rental agreement as well as the rent adjustments currently need to be in a written form including the use of an official form and require an official signature. If this was ensured, the fully integrated process of the key activities of a property management company on a blockchain would be very efficient, transparent and traceable.

1. Introduction

1.1 Motivation

Blockchain technology has increasingly gained popularity in recent years. Especially digital currencies using cryptography for security that can be used to buy products or services, called cryptocurrencies, have been largely debated in the media. Blockchain, the technology behind Bitcoin, can however not only be used for cryptocurrencies although it was originally developed for that purpose. The term blockchain refers to a technical concept, which does not store data in a central databank, but stores the data distributed on the systems of the users (Burgwinkel, 2016, p. 3). Data is stored in individual blocks, which are then stored on the systems of the network participants. The chronological order of the blocks is documented through a chain – hence, the term blockchain (Burgwinkel, 2016, p. 3). The technology is transparent, time-stamped and decentralized. This decentralized, permanent and transparent way of recording transactions removes the need for third-party authentication, providing extremely efficient processes (Marr, 2018). The removal of third-party authentication solves the problem of trust between parties, as they can trust the system without trusting the other parties involved in a certain transaction. Using blockchain can thus dramatically reduce costs of transactions and overcome the typical principal-agent dilemma that many companies face (Voshmgir & Kalinov, 2017, p. 8). The principal agent theory describes the dilemma that is faced when one entity (agent) can make decisions impacting another entity (principal). Agents can sometimes be motivated to act in their own best interests, which might not be identical to those of the principal, thus creating a moral hazard (Grossman & Hart, 1983, pp. 7–8).

Blockchain has developed into a technology with the potential to impact every industry and according to Forbes, nearly 15% of financial institutions are currently using blockchain, with many other industries exploring ways in which to deploy it too (Marr, 2018). Within the real estate industry, there are many opportunities, from notary to land registries to the process of selecting tenants. Multiple countries have started looking at the implementation of blockchain for their land registry; some of those include Brazil, India, Russia, Sweden, Ukraine and the UK. In the Swiss real estate market, there are quite a number of companies working on potential applications, not only using blockchain, but digitalization in general. Terravis for example, a company that belongs to the SIX Group, is developing an electronic information inquiry portal for the land registry. This will be a tremendous move forward for Switzerland’s land registry, as it is currently

decentralized and managed by each canton. Each canton has developed a different system and those are usually not compatible with each other. Having a unified system with land registry data of all cantons in one central place would lead to efficiency gains in obtaining data. This could result in lower costs and less time spent obtaining information from different cantons. However, it does not necessarily need to be a blockchain solution. Having the land registry on the blockchain is especially beneficial in countries where corruption is high and thus trust in central authorities is low (Kshetri & Voas, 2018, p. 12). In Switzerland however, trust in central authorities is very high and corruption is low, meaning that there might not be as many benefits from transitioning the land registry to the blockchain. Nevertheless, there is a company called blockimmo currently working on bringing the land registry system in Switzerland to the blockchain.

Blockchain has gained popularity in the Swiss real estate industry when Swiss Prime Site announced that they are working on a blockchain solution for escrow accounts. Not only escrow accounts and deposit payments but also other processes within the tenant on-boarding process are currently offline and paper-driven, requiring mutual trust. Therefore, the possibilities of how to employ blockchain technology in a property management company will be analysed. Property management companies offer a suitable case to employ blockchain technology. The processes could be made more efficient using smart contracts, which are self-executing computer codes in a blockchain setting that automatically trigger execution when certain conditions are met. Furthermore, through the use of blockchain, payments, data sharing and data processing could all be made more efficient, less costly and more secure. This could potentially reduce the principal-agent problem between tenants and property manager and also between property managers and property owners. The thesis thus aims at depicting the possibilities of using blockchain technology in property management companies.

1.2 Problem definition and objective

The property management business deals with many processes that are still offline, paper-driven and require trust between parties. Furthermore, property management companies face a two-fold principal-agent problem. The principal-agent problem usually arises when there is information asymmetry between two parties and the incentives are not aligned. A property management company is dealing with the property owner, with the property management company being the principal, as it generally knows more than the owner.

Further, a property management company is dealing with the tenant, and in this relationship is in the position of the agent, with the tenant potentially not disclosing all the information.

This thesis aims to provide an understanding of how the processes within a property management company can be made more efficient, secure and less costly while at the same time overcoming the existing principal agent problem between property managers and property owners but also between tenants and property managers.

1.3 Methodology and delimitations

1.3.1 Methodology

As there is currently not a lot of academic literature in the field of blockchain in the real estate industry, this thesis will take the form of a qualitative case study approach. The case study approach as research method allows for four different types (Ridder, 2017, p. 285):

- Eisenhardt: case study has no theory, implementation of case study though uninfluenced from prior knowledge
- Yin: case study is used to “fill gaps” in current research
- Stake: social construction of reality is looked at explicitly
- Burawoy: identification of anomalies

As there is some academic literature the approach according to Yin will be used, where case studies help to answer how and why questions of the topic of interest (Yin, 1994, p. 7). Yin defines case studies as a „contemporary phenomenon within its real life context, especially when the boundaries between a phenomenon and context are not clearly evident“ (Yin, 1994, p. 13).

The thesis is structured into the following parts: firstly, blockchain technology will be explained. As the application possibilities for blockchain technology can not only be found in academic literature, but in white papers, journals and blog entries, this part is not focused on academic literature alone. The basic terminology and functionality of the blockchain technology will be looked at in order to build the fundamental basis for reviewing current and potential applications. Using the example of Bitcoin, the aim is to explain why blockchain has the potential to revolutionize industries. As blockchain is a disruptive innovation, a theoretical background of digital transformation, innovation and business model innovation will follow.

As a next chapter, the current business model of property management companies will be analysed in order to identify processes that could be made more efficient and identify areas where blockchain technology could be used. As a next step, the identified processes will be looked at and a use case will be developed.

Through semi-structured interviews with experts in the regarding field, the feasibility of the use case will be analysed. Semi-structured interviews have the advantage that the interviewer is in control of the process, yet is free to follow new leads. Semi-structured interviews often include open-ended questions providing an instruction set for interviewers. As the questions are open-ended, discussions may arise and particular topics or responses may be explored more deeply. The responses usually provide valuable insights of the participants' experiences (Bernard, 1998, p. 353). A general conclusion will be drawn and further development areas identified.

1.3.2 Delimitations

This thesis aims at describing a potential use case of blockchain technology in the property management business in Switzerland. Due to country-specific laws and regulations, it cannot be generalized for other countries. Furthermore, the processes and use cases looked at are focused on property management companies operating in the rental apartment sector. The developed use case therefore is for apartment buildings and might need to be modified for commercial properties. The potential use case will be of theoretical nature and a potential implementation would need to be tested and verified by a technology specialist in the field of blockchain technology.

1.4 Definition of topic specific expressions

- Blockchain application – for the realization of a specific use case, typically with help of blockchain Software or on a blockchain Platform
- Blockchain software – Software that enables the programming code to perform cryptographic procedure
- Blockchain technology – technical concept
- Cryptocurrency – a digital currency such as Bitcoin
- Cryptography – science of analysing and deciphering code
- Genesis block – the first block within a blockchain
- Hash value – A hash function is an algorithm, which converts a data set into a string of a fixed length, thus a hash function reduces a data set of any length into a combination of letters and/or numbers of a fixed length

- Incentive mechanisms – participants are rewarded for participating
- Node – participant of the network
- Open-source – Anyone with working internet and a computer can participate in the process
- Private key – used to generate a signature for each blockchain transaction a user sends out. The private key should only be known to the specific user and is used to derive the public key
- Public key – the private key is transformed to produce an address other people can see when someone sends a transaction
- Wallet – program allowing you to store and exchange your digital currency

2. Blockchain technology

2.1 History and development

Blockchain is the technology behind Bitcoin. It first appeared in 2008 in a white paper by an anonymous author/author group under the pseudonym of Satoshi Nakamoto. The whitepaper *Bitcoin: A Peer to Peer Electronic Cash System* described a "purely peer-to-peer version of electronic cash" (Nakamoto, 2008, p. 1). An open-source project, meaning that everyone with a computer and working Internet can participate, was registered shortly after and the first block within the blockchain – the genesis block – was established on January 3rd 2009 (Barber, Boyen, Shi, & Uzun, 2012, p. 1).

In 2014, it was realized that blockchain has the potential to be used for more than crypto-currencies. "At its core, blockchain is an open, decentralized ledger that records transactions between two parties in a permanent way without needing third-party authentication, thus creating an extremely efficient process and one people predict will dramatically reduce costs of transactions" (Marr, 2018). This process can overcome the typical principal-agent dilemma of organizations. Furthermore, through storing data on the blockchain, the data can be processed further and thus opening up vast opportunities for digitalization (Omohundro & Steve, 2014, p. 19).

2.2 Definition, terminology and basic functionality

Blockchain seems to be the buzzword of the decade. Looking for information regarding a definition of blockchain, many come up: „A blockchain is simply a chronological database of transactions recorded by a network of computers" (Wright & De Filippi, 2015, p. 6). Or in other words, the blockchain describes a technical concept that puts individual data blocks (such as transactions) together in blocks. Every new entry is stored in a new block, ensuring the chronological sequence and integrity of the data. The links of the chain are designed to break when the chain is manipulated and therefore a manipulation of a data block would be noticeable (Burgwinkel, 2016, pp. 5–6). A blockchain can be operated as single instance or as a distributed system. In a distributed approach, data is not stored in a central data bank but rather distributed on the systems of the network participants. Each participant of this peer-to-peer (P2P) network stores a copy of the transaction ledger. Transactions are validated through machine consensus instead of a central authority (Voshmgir & Kalinov, 2017, p. 5). Through this decentralized approach, every participant of the network (called "node") has the same knowledge of the transactions that have occurred without needing to consult with a central databank first (Rosic, n.d.).

The last technology that has disrupted industries was the evolution of the World Wide Web in the 1990s. As the Internet became more mature, it started enabling social media and e-commerce platforms, transforming the way people interact with each other (Voshmgir & Kalinov, 2017, p. 9). This was achieved through "bringing producers and consumers of information, goods and services closer together, and allowed us to enjoy P2P interactions on a global scale" (Voshmgir & Kalinov, 2017, p. 9). However, in this version of a world, there always is an intermediary, a platform in which people trust. Intermediaries can be banks, social network platforms like Facebook or platforms connecting us to Taxi drivers such as Uber. Looking at blockchain from this angle, it might become a next generation Internet, the Decentralized Web (Voshmgir & Kalinov, 2017, p. 9).

> "Blockchain can bring us true P2P transactions without intermediaries, and Bitcoin is the first use case. While Bitcoin is P2P money without banks and bank managers, the same technology that brought us Bitcoin could now allow us to build ridesharing without Uber, apartment sharing without Airbnb, and social media without Facebook and Twitter" (Voshmgir & Kalinov, 2017, p. 9).

Although the Internet has changed the way we socially interact, data is still stored centrally on our devices, USB sticks or in the cloud. Thus data is exposed to risks and a lot of trust is necessary in the institutions storing our data (Voshmgir & Kalinov, 2017, p. 10). The cryptography and game theoretic incentive mechanisms (participants are rewarded for participating and have equal rights) on top of a P2P data architecture opens up the possibility to move away from centralized data structures towards decentralized or entirely distributed data architectures (Voshmgir & Kalinov, 2017, p. 10).

To explain the blockchain technology graphically, a simplified example of the creation of a blockchain will be looked at in figure 1.

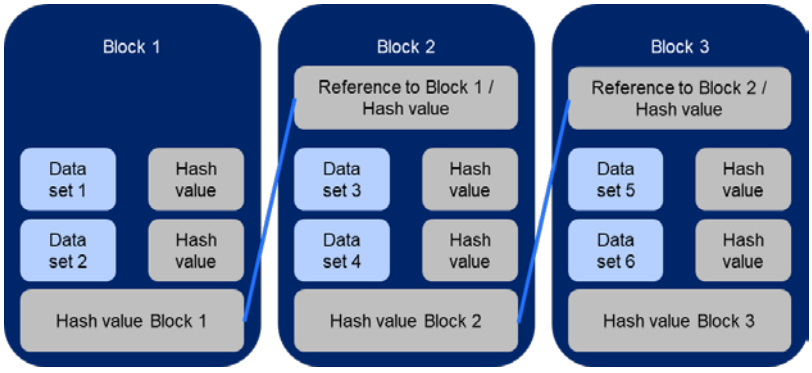

Figure 1: Example of how a blockchain works (based on Burgwinkel, 2016, p. 6)

In this example, a blockchain shall be created that can verify that the data set 1 has been created at the time T1, has not been tampered with and that the chronological order data set 1, dataset 2, dataset 3 has not been manipulated. This simplified example produces two data sets per second, which are summarized in a block and receive a hash value, sequentially linking the blocks and producing a chain of blocks, or blockchain (Burgwinkel, 2016, pp. 6–7). A hash function is an algorithm, which converts a data set into a string of a fixed length, thus a hash function reduces a data set of any length into a combination of letters and/or numbers of a fixed length. This is called the hash value, or hashes (Schlatt, Schweizer, Urbach, & Fridgen, 2016, p. 8). The same data will always result in the same hash; however, vice versa it is not possible to retrieve the original data from the hash it has produced (Simpson, 2017). In the Bitcoin blockchain, hashes are 256 bits, or 64 characters long. The hash is therefore a string with 64 characters that is unique to a specific document and represents a unique identifier for a specific document (Swan, 2015, p. 99). “The hash represents the exact content of original file” (Swan, 2015, p. 37). When content needs to be reconfirmed, the same hash algorithm will be run over the file. If the file has not been changed, the hash signature will be the same (Swan, 2015, p. 37). The cryptographic hashes can therefore be used for asset verification and attestation. “The core functionality is the ability to verify a digital asset via a public general ledger” (Swan, 2015, p. 38). If something in a document is changed, the hash will change and the link to the next block is broken, therefore manipulation and data tampering can easily be detected.

Coming back to the example above, Block 2 is linked to Block 1 and has a reference to the Block 1 hash value. If the two values are not the same, the block is not valid. Simultaneous to the hashing, the data is time-stamped, ensuring that the sequential order of the blocks can be traced back to the origins, or the first block of the chain called the genesis block. The blockchain, consisting in our example of Blocks 1, 2 and 3 is copied to the computers of the network participants. Thus numerous copies exist of the blockchain, stored in a decentralized way (Burgwinkel, 2016, pp. 6–7).

Depending on the concept, information or data can be stored directly on the blockchain, so-called on-chain, or the data in the blockchain can have a reference to external data, so-called off-chain. References to external data might be necessary in the case of a large storage volume or high sensitivity of the data (Burgwinkel, 2016, pp. 6–7). To avoid manipulation of cryptographic calculations, the computing capacity is distributed to different computers, where each computer calculates the cryptographic functions and all computers

agree on the result. This procedure is called the consensus procedure (Burgwinkel, 2016, pp. 7–8). A participant in the system is called a node. The node that was first in having the correct result executes the building of the block. If the blockchain is operated with a cryptocurrency, the node is rewarded with a certain amount of cryptocurrency, which are the native tokens of public blockchains (Burgwinkel, 2016, pp. 23–24). The process in which the nodes participate in validating transactions is called mining (Voshmgir & Kalinov, 2017, p. 16).

2.3 Different types of blockchains

Blockchains can be public, private or within a consortium, also called federated blockchain and can further be permissionless or permissioned.

2.3.1 Public blockchain

A public blockchain is open-source and permissionless, based on consensus algorithms. This means that everyone with access to the Internet can participate and approve transactions. A public blockchain operates with a game-theoretic incentive mechanism, encouraging new participants to take part in the network and validate transactions. Due to the public nature, anyone with working internet and a computer can start running a node on their device and can participate in the consensus process. A public blockchain has "the potential to disrupt current business models through disintermediation and no infrastructure costs: no need to maintain servers or system admins radically reduces the costs of creating and running decentralized applications" (Voshmgir & Kalinov, 2017, p. 14)

An example of a public, open-source blockchain is Bitcoin. Transparency is essential for participants to run the nodes and trust the network, as miners need full transparency of the transaction information to validate the pay-out they receive as an incentive for mining against the work performed by their respective nodes. In a permissionless blockchain, miners and participants can stay anonymous to some extent, or in case of the Bitcoin blockchain, use a pseudonym (Kadiyala, 2018). Permissionless blockchains such as Bitcoin currently have issues with scalability and performance, however, it is believed that these are just early stage hiccups and that these issues will be resolved once the system becomes more mature (Kadiyala, 2018).

2.3.2 Permissioned blockchain

A permissioned blockchain is a closed ecosystem in which each participant is defined. In contrast to a permissionless blockchain, participants are identified and trusted. Information can be exchanged and transactions recorded by organizations or a consortium.

Members of a consortium run the permissioned blockchain. Only preapproved entities can run the nodes and participate in the process of validating transactions. Most permissioned blockchains have no system of rewarding miners with tokens, but rather miners are incentivized to minimize cost, time and ease of sharing information. Privacy is an important factor with permissioned blockchains and visibility of transaction details is often fine-grained (Kadiyala, 2018). Permissioned blockchains can be consortium/federated blockchains or private blockchains. It is worth mentioning that using the term blockchain in the context of permissioned ledgers is largely debated (Voshmgir & Kalinov, 2017, p. 21). However, for the purpose of this thesis, it will be referred to as permissioned blockchain.

Federated blockchain

A consortium or federated blockchain is operated in a closed group and not every person can participate. Transactions can only be verified by a selected number of participants (Voshmgir & Kalinov, 2017, p. 14). Federated blockchains tend to be faster than the public blockchains. However, they also tend to provide less transaction transparency. Consensus is reached by a pre-defined set of nodes. “One might imagine a consortium of 15 financial institutions, each of which operates a node and of which 10 must sign every block in order for the block to be valid” (Voshmgir & Kalinov, 2017, p. 14). The right to read entries on the blockchain can be public or restricted to the participants (Voshmgir & Kalinov, 2017, p. 14). A federated blockchain can be compared to SAP in the 1990s – it helps with cost reduction, making document handling easier and automating certain manual processes, however, it is not as disruptive as a public blockchain (Voshmgir & Kalinov, 2017, p. 14).

Private blockchain

A private blockchain is restricted to an organization or individual and is owned by either one. Write permissions are centralized to one organization or individual while read permissions may be public or restricted. A private blockchain network can only be joined by invitation and a validation of new participants is required (Voshmgir & Kalinov, 2017, p. 14). Applications working with a private blockchain might be database management or auditing, which are internal to a single company. Groups and participants are set up internally to verify transactions. This makes the system centralized again and the system is no longer secured by game theoretic incentive mechanisms (Voshmgir & Kalinov, 2017, p. 14).

An overview of the different types of blockchains and their respective functionalities can be found in the table below. The consensus mechanism will be explained in the next chapter.

	Public No centralized management	**Consortium** Multiple organisations	**Private** Single organisation
Participants	Permissionless • Anonymous • Could be malicious	Permissioned • Identified • Trusted	Permissioned • Identified • Trusted
Consensus mechanisms	Proof of Work, Proof of Stake, etc. • Large energy consumption • No finality • 51% attack	Voting or multi-party consensus algorithm • Lighter • Faster • Low energy consumption • Enable finality	Voting or multi-party consensus algorithm • Lighter • Faster • Low energy consumption • Enable finality
Transaction approval frequency	Long Bitcoin: 10min or more	Short 100xmsec	Short 100xmsec
Unique selling proposition	Disruptive Disruptive in the sense of disintermediation. No middle men needed. Unclear what the business models will be.	Cost Cutting Can radically reduce transaction costs. Similar to SAP in 1990s. Extreme cost cutting opportunities. Less data redundancy, higher transaction times, more transparency.	Cost Cutting Can radically reduce transaction costs. Similar to SAP in 1990s. Extreme cost cutting opportunities. Less data redundancy, higher transaction times, more transparency.

Table 1: Overview of different types of blockchains (based on Voshmgir & Kalinov, 2017, p. 17)

2.4 Consensus mechanism

The decentralized consensus building is one of the key aspects of the blockchain technology. Different consensus mechanisms exist and they ensure that data recorded on the blockchain is valid. This is important to ensure reliability of the system even if some participants do not act in the general interest. The consensus mechanism is derived from the Byzantine Fault Tolerance Concept, based on the Byzantine Generals Problem. The Byzantine Generals Problem is a deviation from the Two Generals Problem. The Two Generals Problem describes a scenario with two generals, General 1 being the leader and General 2 being the follower, wanting to attack a common enemy. In order to defeat the enemy successfully, they need to attack together at the same time. However, to communicate with each other, General 1 needs to send a messenger across the enemy's camp, delivering the time of attack to General 2. The option exists, that the messenger gets captured and the message will never be delivered, resulting in General 1 attacking and General 2 waiting. If the first message gets through, General 2 needs to acknowledge

that the message was received. For that, a messenger is sent back, again with the possibility that the messenger gets captured and the message is lost. This scenario repeats itself infinitely and generals are unable to reach an agreement - a problem that has proven to be unsolvable (Pease, Shostak, & Lamport, 1980, pp. 2–3). Lamport, Shostak and Pease described a generalized version of the Two Generals Problem with a complication, called the Byzantine Generals Problem (Lamport, Shostak, & Pease, 1982, pp. 382–384). This scenario has the added complication that there are more than two generals that need to agree on a time to attack their common enemy. The complication added is that one or more of the generals could potentially be traitors, lying about their time of attack. The Two Generals Problem describes a leader-follower paradigm, whereas the Byzantine Generals Problem describes a commander-lieutenant setup. To reach consensus, the commander and every lieutenant need to agree on the same decision. The algorithm in the offered solution suggests that consensus can be reached as long as 2/3 of the participants are honest. Figure 2 describes two scenarios. In one, Lieutenant 3 is a traitor and in 2, the commander is a traitor. In the first figure, taking the view of Lieutenant 2, the commander sends the message to all lieutenants. The lieutenants send the received message to other lieutenants. The traitor, lieutenant 3, sends a different message than he received. The final decision is based on a majority vote from the three lieutenants and consensus can been reached. In the second figure, the commander is a traitor, sending different message to all lieutenants, x, y and z. All the lieutenants receive the same value, which is x, y, z. However, although consensus is reached, the messages are totally different and the assumption can be made that they decide for the default option, which is retreat (Lamport et al., 1982, pp. 382–387).

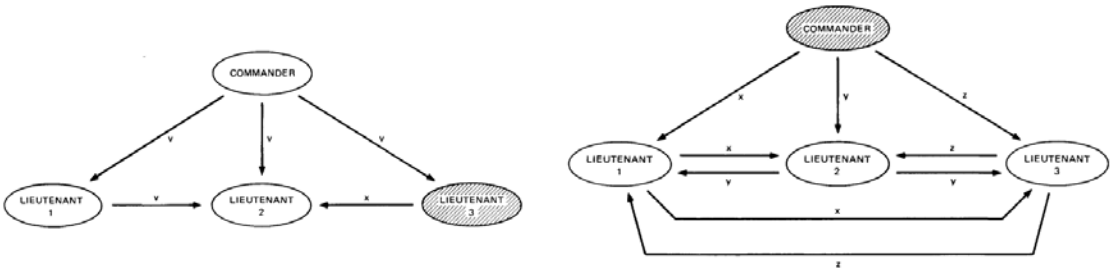

Figure 2: Byzantine Generals Problem graphically explained (Lamport et al., 1982, p. 389)

The failures belonging to the Byzantine Generals Problem are tolerated by a system with specific characteristics, called Byzantine Fault Tolerance. In a distributed system, consensus algorithms ensure transaction validity and transparency of transaction records

across the network. As no central authority is responsible for this, transactions are validated by the participants (Puthal, Malik, Mohanty, Kougianos, & Yang, 2018, p. 1). Thus, participants might have an incentive to behave as a traitor. A solution to this problem in the form of a consensus mechanism is needed to ensure that the data records on the blockchain are not compromised and account for maliciousness (Baliga, 2017, p. 3). This is especially necessary in permissionless systems, where everyone is allowed to participate in the process of validating transactions.

Permissioned systems only have known participants as nodes, which are part of the consortium. As a consequence, trust in a permissioned system is higher than in a permissionless system. Thus, due to different levels of trust, alternative consensus mechanisms can be used such as voting or multi-party consensus (Baliga, 2017, p. 3).

The two most common consensus algorithms in a permissionless setting will be explained, which currently are Proof-of-Work (PoW) and Proof-of-Stake (PoS) (Baliga, 2017, pp. 3–8).

2.4.1 Proof-of-Work consensus algorithm

PoW was the first blockchain consensus algorithm used for Bitcoin and other cryptocurrencies. PoW requires energy and time in the form of computing power to ensure the security. An economic system is created were participants need to incur costs to participate for the probabilistic likelihood of receiving a reward (with the probability in line with the hashing power dedicated to the network), such as Bitcoin tokens in the case of Bitcoin. “The consensus rules are defined in a way that it doesn’t pay to cheat. The simple game theoretical equilibrium is the core of the Bitcoin consensus algorithm” (Voshmgir & Kalinov, 2017, p. 19). The PoW method asks participants to run hashing algorithms to validate transactions, thus proofing that they have performed work to validate the transactions – “Proof-of-Work”. The PoW method is rather slow and uses a lot of energy (Baliga, 2017, pp. 6–7).

2.4.2 Proof-of-Stake consensus algorithm

The fundamental idea behind the PoS algorithm is that participants are asked to prove ownership of a certain amount of currency – their stake in the currency (Voshmgir & Kalinov, 2017, p. 19). This is opposed to the PoW algorithm, where participants need to run computing power through running hashing algorithms. In the PoS method, participants need to prove their stake in the cryptocurrency. Increases in stake of the cryptocurrency increases the likelihood of being able to generate a block (Voshmgir & Kalinov,

2017, p. 19). While mining through the PoW method comes at a high cost in the form of computing power to participants, mining with PoS is free for the participants, which can create the nothing-at-stake problem (Voshmgir & Kalinov, 2017, p. 19). This can happen when participants are not incentivized for voting on the correct block. As mining does not come at a high cost in a PoS system, participants can vote on multiple blocks and thereby maximizing the chance of receiving a reward. This problem needs to be addressed in order for the PoS method to be implemented correctly (Baliga, 2017, p. 8).

2.5 Transactions in blockchain

Advanced cryptographic techniques are used to ensure the legitimacy of a transaction source and that funds cannot be stolen. Let's look at the basic principle of the Bitcoin blockchain to understand how transactions in a blockchain work. One Bitcoin is one unit of the Bitcoin (BTC) digital currency, just like one Swiss Franc (CHF). In order to keep track of the amount of Bitcoins every person owns, the blockchain uses a ledger, which is a digital file keeping track of all Bitcoin transactions (D'Aliessi, 2016). It is basically a spreadsheet that is duplicated thousands of times across a network of computers, which is updated regularly (D'Aliessi, 2016). Through this network, the ledger is not stored centrally, like at a bank, but decentral. The distributed network of private computers are storing data and executing computations. If money is now sent from A to B, A sends a message to the network confirming that his account should go down by X BTC and the account of B up by X BTC. The message will be received by every node in the network and they will apply the requested transaction to their copy of the ledger, therefore updating the account balances (D'Aliessi, 2016). The fact that the ledger is distributed and shared has several implications: transactions can be seen by anyone in the network. Further, the distributed, shared ledger is designed in a way that no trust is needed in the other parties, as the outcome of the system can be trusted. This generates security and reliability via special mathematical functions and code. In order to participate in the process and make transactions, a wallet is needed. A wallet is a program allowing you to store and exchange your digital currency Bitcoin, just like in a bank account. A special cryptographic method using a unique pair of different but connected keys protects the wallet. There is a private and a public key. "If a message is encrypted with a specific public key, only the owner of the paired private key will be able to decrypt and read the message. On the other hand, if you encrypt a message with your private key, only the paired public key can be used to decrypt it" (D'Aliessi, 2016). Thus, when a transaction request is made using the wallet's private key, a person is generating a digital signature, used by blockchain computers to being able to check the source and authenticity of the transaction. The

digital signature uses your private key as well as the transaction request and converts it into a string of text. If the transaction request is changed, or a character in the string of text is altered, the digital signature changes, therefore preventing potential hackers from changing transaction requests (D'Aliessi, 2016). The message only broadcast after it has been encrypted and therefore never revealing the private key, which acts like a person's identity. If the private key is stolen, it could be used to execute transactions in another person's name, effectively stealing (D'Aliessi, 2016).

2.6 Different blockchain platforms

Although there are many more blockchain platforms, for the purpose of this thesis only the three most common ones currently will be briefly described: Bitcoin, Ethereum and Hyperledger.

2.6.1 Bitcoin blockchain

The first blockchain was the one developed for using the cryptocurrency Bitcoin. Bitcoin was designed for the purpose of being a decentralized, peer-to-peer payment system (Harm, Obregon, & Stubbendick, 2016, p. 3; Nakamoto, 2008, p. 1). The Bitcoin blockchain is a blockchain software with a focus on a single use case (Jeffries, 2018). The system is a very transparent record of every transaction ever made (Crosby, 2016, p. 7). The fact that the ledger is distributed and shared has several implications: transactions can be seen by anyone in the network. One can trust the outcome of the system, which generates security and reliability via special mathematical functions and code without trusting the other party (D'Aliessi, 2016). This is the basic concept of the Bitcoin blockchain, a permissionless, open-source blockchain. The benefits are that no third party holds your value, the transaction costs are very low and value can be transferred within a short time. Transactions are secure, verifiable and transparent (D'Aliessi, 2016). Bitcoin uses the Proof-of-Work consensus algorithm with nodes being rewarded with Bitcoins.

2.6.2 Ethereum blockchain

Ethereum on the other hand was not designed to be a payment system only and was developed in 2014. Participants in the Ethereum blockchain are rewarded with Ether, a type of crypto token that fuels the network. Ether is not only used as a cryptocurrency, but also by application developers to pay transaction fees and services on the Ethereum network. The Ethereum network allows developers to create any operation that they want, thus opening up an almost unlimited amount of opportunities to build blockchain applications. "Before the creation of Ethereum, blockchain applications were designed to do a very

limited set of operations. Bitcoin and other cryptocurrencies, for example, were developed exclusively to operate as peer-to-peer digital currencies" (Rosic, 2016). Using the Ethereum blockchain, centralized services can be decentralized. This includes services such as banks, voting systems and also land registries (Rosic, 2016). These decentralized applications, as outlined by Rosic will profit from all benefits the blockchain has to offer (Rosic, 2016).

- Immutability – A third party cannot make any changes to data.
- Corruption & tamper proof – Apps are based on a network formed around the principle of consensus, making censorship impossible.
- Secure – With no central point of failure and secured using cryptography, applications are well protected against hacking attacks and fraudulent activities.
- Zero downtime – Apps never go down and can never be switched off.

2.6.3 Hyperledger Fabric

The Linux Foundation published the Hyperledger project in 2015 with the goal of providing a blockchain-based open source technology through which companies will be enabled to build robust and industry-specific systems for secure transaction processing (Burgwinkel, 2016, p. 111). Many different companies collaborate and contribute to the Hyperledger project and build frameworks. The new version of the Hyperledger blockchain is called Fabric. If Hyperledger is referred to in the following chapters, the text is about its current version Fabric. It is a permissioned blockchain, with an architecture composed of different services and central components. The components are provided via plug-ins and thus provide the opportunity to build systems tailored to ones requirements. Hyperledger does not provide a cryptocurrency, however, as the consensus mechanism is based on a plug-in, the option exists to run the system with a cryptocurrency. Lastly, there is a cryptographic plug-in, as Hyperledger does not define a specific cryptographic algorithm (like for example the secure hashing algorithm SHA 256 for Bitcoin) and therefore depending on the plug-in, different algorithms are used. Through the open plug-in architecture, the system can be adapted to changes in the future (Burgwinkel, 2016, pp. 114–115).

2.7 Applications of blockchain technology

The following figure provides an overview of some of the application possibilities of a blockchain.

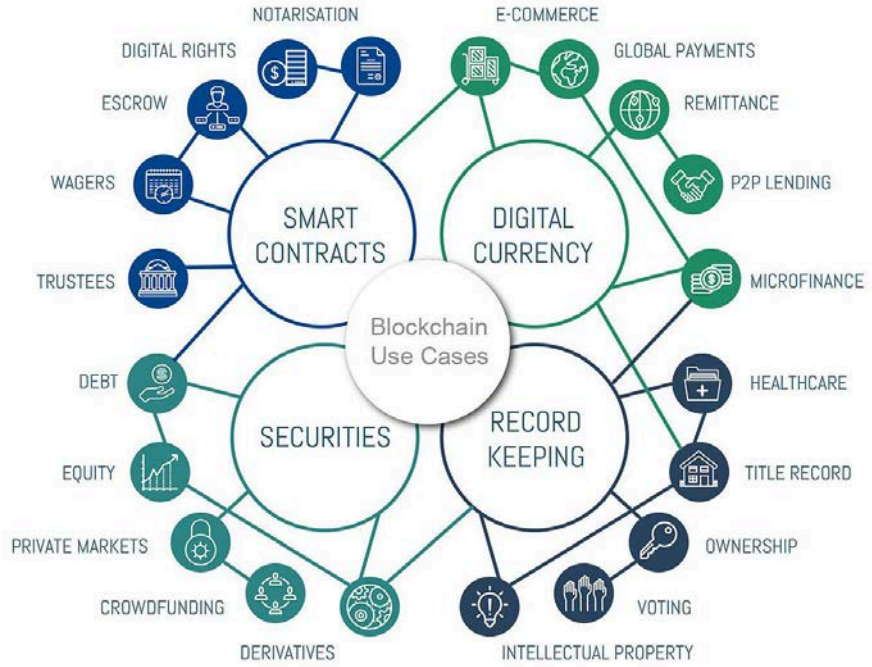

Figure 3: Blockchain use cases (Bergstrom, 2017)

The use cases can be categorized into four categories: digital currency, record keeping, securities and smart contracts.

2.7.1 Digital currency

Digital currencies such as Bitcoin can be used for e-commerce, payments, remittance, P2P lending and microfinance. The essential part is that the bank (the third party in this use case) is no longer necessary.

2.7.2 Record keeping

Using blockchain for recordkeeping creates a secure, transparent and public ledger of the entries. This is especially useful in corrupt countries for things such as land registries as “insecure land registries may create opportunities for corrupt politicians to acquire properties that they are not entitled to by fraudulently entering title transfers” (Lemieux, 2016, p. 110). Data integrity can be ensured using blockchain technology, meaning that there is proof that data has not been tampered with (Burgwinkel, 2016, p. 13). This data integrity is ensured through the hash value. Using blockchain for recordkeeping can thus be useful for any area of use where it might be beneficial to have a proof that data has not been manipulated or changed. Examples include research data for new medicine or diagnosis

in health care, but also other things such as voting, title recording, property rights or intellectual property.

2.7.3 Securities

As technology advanced, trading securities has become easier. However, through the increasing numbers of intermediaries, holding assets has become more complex (Micheler & Heyde, 2017, p. 652). Currently, electronic marketplaces such as exchange trading or internet auctions mostly include a central instance for the transaction process, such as a stock exchange or an auction platform (Burgwinkel, 2016, p. 18). “In a direct holding system investors are only exposed to risk associated with the issuer. In an intermediated model, in addition to the issuer’s risk investors bear the risk of all intermediaries that act between them and the issuer” (Micheler & Heyde, 2017, pp. 652–653). Through the use of blockchain, these intermediaries can be reduced, enabling direct interaction of buyer and seller (Micheler & Heyde, 2017, p. 653).

2.7.4 Smart contracts

Lastly, smart contracts, which can auto-enforce transactions based on pre-defined conditions, can make processes such as notarisation, digital rights, escrow, wagers and trustees more efficient and secure. As early as 1994, Nick Szabo, a legal scholar and cryptographer, realized the potential of the decentralized ledger for smart contracts or self-executing contracts. According to him, smart contracts would improve execution of the four basic contract objectives, which Szabo described as observability, verifiability, privity and enforceability (Szabo, 1996).

The Ethereum project decoupled the contract layer from the blockchain, introducing smart contracts to the blockchain context. A smart contract describes a computer code that can facilitate the exchange of money, content, property shares, or anything of value. The self-execution is triggered when the pre-defined conditions are met (Rosic, 2016). “Because smart contracts run on the blockchain, they run exactly as programmed without any possibility of censorship, downtime, fraud or third party interference” (Rosic, 2016). This offers significantly reduced transaction costs while at the same time significantly increased transaction security (Rosic, 2016). Figure 4 shows the basic functionality of a smart contract.

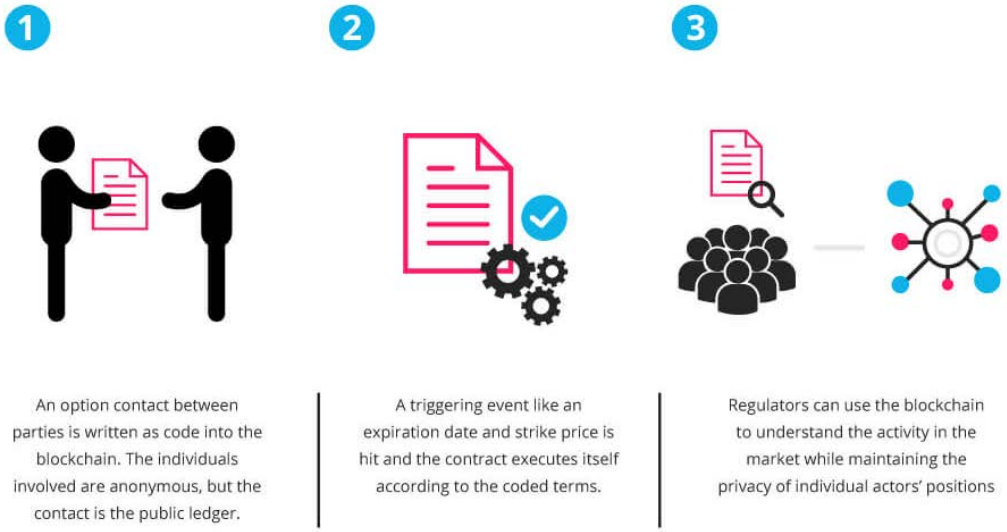

Figure 4: How smart contracts work (Rosic, 2016)

Smart contracts can be used for simple transactions such as sending money but also for registering ownership and property rights such as land and registries or managing smart access control for the sharing economy. They can of course also be used for more complex transactions (Voshmgir & Kalinov, 2017, p. 7). Thus, the future of blockchain and smart contracts will mean that contracts are embedded in digital code, stored in a transparent and shared database offering protection against tampering, changing or deleting (Iansiti & Lakhani, 2017). "In this world, every agreement, process, task and payment would have a digital record and signature that could be identified, validated, stored and shared. Intermediaries like lawyers, brokers, bankers and public administrators might no longer be necessary. Individuals, organizations, machines and algorithms would freely transact and interact with one another with little friction and a fraction of current transaction costs" (Iansiti & Lakhani, 2017).

2.8 Summary of blockchain benefits and attributes

Efficiency can be increased due to automation and transparency is ensured due to traceable trails. Self-executing smart contracts further enhance efficiency and security. Due to the increased security and transparency, costs for compliance and risk management can potentially be reduced.

The general attributes of the blockchain technology are:

- Distributed: all network participants have a full copy of the ledger
- Anonymous: the identity of participants is either pseudonymous or anonymous
- Time-stamped: transaction timestamp is recorded in a block
- Unanimous: all network participants agree to the validity of each of the records
- Straight through processing

- Immutable: any validated records are irreversible and cannot be changed
- Secure: records are individually encrypted
- Programmable: blockchain is programmable
- Trust: no need for intermediaries

2.9 Blockchain and its potential to disrupt business models

According to an article in the Harvard Business Review, blockchain will do to the financial system what the Internet did to media (Ito, Narula, & Ali, 2017). In order to understand the disruptive nature of the blockchain better, this will be looked at more closely via the example of Bitcoin. The current business model of banks is focused on depositing customers' money in a bank account; make payments, providing loans as well as credit. Put very simply, banks make money through charging fees for services such as depositing money for customers, executing transactions and advising, charging interests on loans and through trading financial instruments. The funds deposited at a bank by customers are used for lending. Of course the business model of banks is much more complex, with many intermediaries and different areas of services. For a customer, the bank acts as a trusted third party, a central authority. Bitcoin presents a solution to the centralized function banks haves. Trust is ensured through the system, making peer-to-peer transactions possible. This will completely change the business model of the banking industry. Banks need to find new ways of doing business, as the old business model with a bank as an intermediary will become obsolete with the raise in peer-to-peer solutions. Through the removal of intermediaries, a decentralized financial system could be less complex. "It could help insure against risk, and by moving money in different ways could open up the possibility for different types of financial products" (Ito et al., 2017). As such, through employing blockchain technology, the business model of financial systems could change. "For the first time in history assets can be transferred peer-to-peer without an intermediary using an Internet of value" (Tapscott, 2018, p. 3). The Bitcoin example has shown that the technology will eventually carve out the need for banks to execute transactions. Not surprisingly, banks are already heavily working on ways to implement the technology. Over 70 global banks have grouped themselves to form the R3 consortium, which collaborated to create the financial-grade open source Corda blockchain platform. McKinsey analysed the impacts of blockchain technology on many different industries using analysis and also interviews. According to their study, blockchain's initial impact will be to drive operational efficiency. Costs can be reduced as some intermediaries will

become unnecessary or certain administrative tasks will become much more effective using blockchain. New revenue streams might evolve for companies offering blockchain services. Furthermore, the study quantified the monetary impact for the analysed cases. The estimation is that "approximately 70 percent of the value at stake in the short term is in cost reduction, followed by revenue generation and capital relief" (Carson, Romanelli, Walsh, & Zhumaev, 2018, p. 6). As the technology matures, McKinsey believes that the value will shift to enabling new business models and revenue streams (Carson et al., 2018, pp. 6–8).

In the banking industry, blockchain is of such disruptive nature that not only certain processes but also the overall business model will change. Considering the large impact blockchain can have on the business model of the banking industry, it is important to analyse the impact it could have on other industries, such as the real estate industry and in particular property management companies. In order to do that and to define the meaning of business model innovation, the theory behind digital transformation, innovation and business model innovation will be looked at before identifying a potential use case for blockchain technology in property management companies.

3. Theoretical concepts

3.1 Digital transformation

Currently, there is not one single definition of digital transformation. Digital transformation can be explained as integrated networking of all economic areas and as adjustment of the actors to the new circumstances of the digital economy (Bouée & Schaible, 2015, p.6). At a minimum, digital transformation integrates digital technologies into existing businesses. More profound changes in the business models are also considered, with substantial changes in the cost and revenue structure. Through this integration, the way a company operates is impacted. Digital transformation contains the word transformation, which is defined as "a whole scale change to the foundational components of a business: from its operating model to its infrastructure" (King & Leonard, 2013). Thus, transformation is a change affecting all parts of the value chain of a business. The drivers for transformation are changing consumer demand, changing technology and changing competition (King & Leonard, 2013). The word digital has different meanings to different authors; it can be about technology only, or a new way of interacting with clients or a new way of doing business. In the broad sense, digital is "any technology that connects people and machines with each other or with information" (King & Leonard, 2013). Thus,

in essence, digital transformation is a complete change to the foundational components of a business through any technology connecting people and machines with each other or with information. As such, advances in technology have the potential to disrupt businesses and industries and change the way they are operating. In the 1990s, funds were invested into new information technology such as web sites, mobile communications and other digital technologies (Andal-Ancion, Cartwright, & Yip, 2003, p. 34). These investments essentially changed the ways people communicate and interact, proving the disrupting nature that digital transformation not only has on businesses but also on everyday life. Due to this disruptive nature of digital transformation, a cultural change is often required in organizations, as the current way of doing business will be replaced by new processes and business models. A company requires a digital culture, a culture that supports change and helps the company achieve its strategy (Hemerling, Kilmann, Danoesastro, Stutts, & Ahern, 2018). One of the key findings of a survey conducted by MIT Sloan Management Review in collaboration with Deloitte was "The strength of digital technologies — social, mobile, analytics and cloud — doesn't lie in the technologies individually. Instead, it stems from how companies integrate them to transform their businesses and how they work" (Kane, Palmer, Philips Nguyen, Kiron, & Buckley, 2015, pp. 4–5). Furthermore, companies that are successful in integrating new technologies and being able to transform their businesses have a clear digital strategy in combination with a culture and leadership that foster transformation (Kane et al., 2015, p. 5).

With emerging technologies, the largest impact can be seen in IT departments. There seems to be a shift from companies simply running IT for operations and reduced costs to IT becoming the driver for business innovation. 63% of respondents in the 2016 Harvey Nash/KPMG CIO Survey of over 3,300 CIOs state that their CEOs wants the IT organization to focus on how to make money rather than how to save money (Ellis & Heneghan, 2016, p. 4). Top managers are getting more and more interested in their IT department and think about how they can get a competitive advantage through the use of new technologies in their business models (Carr, 2003).

To summarize, in an era of digital transformation, the most successful companies are the ones coming up with new ways of doing business and changing existing business models to new, technology driven models. Thus, companies need to innovate their existing business models and processes in order to being able to compete in the changing environment we are currently in.

3.2 Innovation

Innovation can be defined as the process of translating an idea or invention into a good or service that creates value or for which customers will pay. According to an analysis of leading businesses, it was found that „companies with a cohesive plan for integrating the digital and physical components of operations can successfully transform their business models“ (Berman, 2012, p. 16). The focus of these companies seems to lie in reshaping customer value proposition and transforming their operations using digital technologies for greater customer interaction and collaboration (Berman, 2012, p. 16).

In order for a company to start thinking about innovations, there needs to be a certain need for innovation in the first place. The possible drivers for innovation can be classified into three categories: problem-driven innovation, constraint-driven innovation and opportunity-driven innovation. As the names suggest, problem-driven innovation is driven through some unsatisfactory product, service or process. Constraint-driven innovation happens, when boundaries in an organization hinder the ability to execute certain processes or routines. Opportunity-driven innovation is when innovations are thought of not because of an urge to change but due to the realization of an opportunity. It is not reactive, as the other two types are, but proactive. Opportunity-driven innovation can for example be triggered with advancements of a new technology (Rosemann, 2012, pp. 2–4). Thus, blockchain technology might trigger opportunity-driven innovations in companies, as the new technology opens up many opportunities and possibilities of changing the ways of doing business. In theory, four main forms of innovation can be distinguished, which are summarized in the figure below (Rosemann, 2012, pp. 1–2).

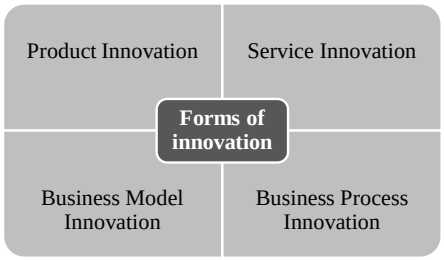

Figure 5: Four types of innovation (Rosemann, 2012, p. 1)

Product innovation was the focus of attention for many years. Important for this type of innovation are economies of scale when building new products (Utterback & Abernathy, 1975, p. 644).

Service innovation has started to become more popular due to technological advancements. Service innovation can be defined as

> "A service innovation is a new service experience or service solution that consists of one or several of the following dimensions: new service concept, new customer interaction, new value system/business partners, new revenue model, new organizational or technological service delivery system" (Den Hertog, Van Der Aa, & De Jong, 2010, p. 494).

Process innovations involve process re-designing activities and usually are focused on process analytics (Rosemann, 2012, p. 1).

Business Model Innovation is the most substantial innovation of the four, as it will disrupt and change the way a company is doing business. Designing innovative processes has the power to transform a business model or an entire industry. The four types of innovations are largely interlinked, as the implementation of new products or services might require process innovations, which could potentially provide opportunities for business model innovations. Examples of business model innovations are Apple with iTunes, the online music service and Xerox. Apple has successfully redefined the market for buying music through providing a business model for downloading music. This combination of product and business model innovation has made Apple the company with the highest market value in the world (Zott & Amit, 2010, p. 221). Xerox introduced a new technology for copy machines, resulting in a product that was too expensive for the market to accept. Xerox decided to market the product itself through the development of a new business model: Xerox leased the equipment to customers at a low cost and charged per copy fees in excess of a certain number of copies per month, thereby changing the business model they originally had (Chesbrough & Rosenbloom, 2002, pp. 536–541).

Both, Apple and Xerox have completely reshaped the way of doing business in their particular markets and have come up with new ways of delivering customer value.

For companies to be ready to innovate on their business models, the tools needed will be looked at.

3.3 Business model innovation

A new technology such as blockchain has the potential to encourage opportunity-driven innovation. As the technology is rather disruptive, it fosters business model innovations. “A mediocre technology pursued with a great business model may be more valuable than a great technology exploited via a mediocre business model” (Chesbrough, 2010, p. 354). Thus, technology only creates economic value if it can be commercialized through the business model. A company can create revenue through their business model by using technology and its potential and changing them into an economic output. To create economic output and generate value from a technology, customers and markets are necessary (Chesbrough, 2006, p. 108). “The business model is a useful framework to link ideas and technologies to economic outcomes” (Chesbrough, 2006, p. 108). Value creation and value capture are at the core of a business model (Chesbrough, 2006, p. 108).

With the large adoption of the Internet in the 1990s, it was believed that a web-based business model promising tremendous profits in the future is the only thing necessary for a company to succeed (Magretta, 2002). However, a good business model, is essential for a company to succeed and the study of business model experimentation and innovation started to become popular. A good business model should answer the questions of who the customer is, what the customer values, how a business makes money and what the economic logic is explaining how value can be delivered at an appropriate cost. Further, a business model should tell a story about how the business works (Magretta, 2002). The business models of many firms have drastically changed with the emergence of post-industrial technologies and evolved in the past decades. These factors have led researchers towards a systematic study of business models as companies are increasingly forced to rethink their supply chain and develop new business models or adapt the current ones (Massa & Tucci, 2013, p. 422). Two complementary roles for the business model in enhancing innovation have been mentioned by Massa & Tucci: “First, Business Models allow innovative companies to commercialize new ideas and technologies. Second, firms can also view the Business Model as a source of innovation in and of itself and as a source of competitive advantage” (Massa & Tucci, 2013, p. 424). New companies can be created around a new business model. If this is the case, the creation, implementation and validation of the Business Model is defined as Business Model Design. The changing of an existing business model is defined as Business Model Reconfiguration (Massa & Tucci, 2013, pp. 424–429).

The purpose of this thesis is to look at how the business model of a property management company might change with the emergence of blockchain technology. Therefore, only Business Model Reconfiguration will be looked at.

Business Model Reconfiguration

In existing businesses, innovations are subject to more issues, as the existing businesses usually consider their way of doing business as the right one. This dominant logic is the existing notion of how the firm competes (Prahalad, C.K. and Bettis, 1996, pp. 389–391). This can prevent managers from identifying opportunities if these are not within the existing logic, falling into the dominant logic trap (Chesbrough, 2010, p. 362). Further, companies have the risk of falling into the identity trap, referring to the fact that an entity's identity can hinder opportunities and can lead to the firm not being able to handle changing circumstances if these changes are not compatible with the identity (Bouchikhi & Kimberly, 2003, p. 22). Barriers to change in a firm due to one of those traps need to be overcome and many tools are suggested in literature to overcome these barriers. Essentially, processes need to be created to enable innovation and improvements (Mitchell & Coles, 2003, p. 21). Behavioural aspects of top management and their commitment are of high importance to innovate business models (Doz & Kosonen, 2010). The current model needs to be analysed in detail to understand the limitations. Once the current business model is fully understood, it might be easier to identify new opportunities (Lindgardt, Reeves, Stalk, & Deimler, 2009). A well-established method to visualize current business models and position them for innovation is the Business Model Canvas (Osterwalder, Pigneur, & Smith, 2009, p. 15).

Business Model Canvas

The Business Model Canvas, developed by Osterwalder, describes a business model through nine basic building blocks, which show how a company intends to add value. Each of the building blocks defines a certain stakeholder and addresses questions that need to be answered. The nine building blocks are customer segments, value propositions, channels, customer relationships, revenue streams, key resources, key activities, key partnerships and cost structure (Osterwalder et al., 2009, pp. 16–41). Using these building blocks, the Business Model Canvas can be designed. Figure 6 illustrates how the Canvas looks like.

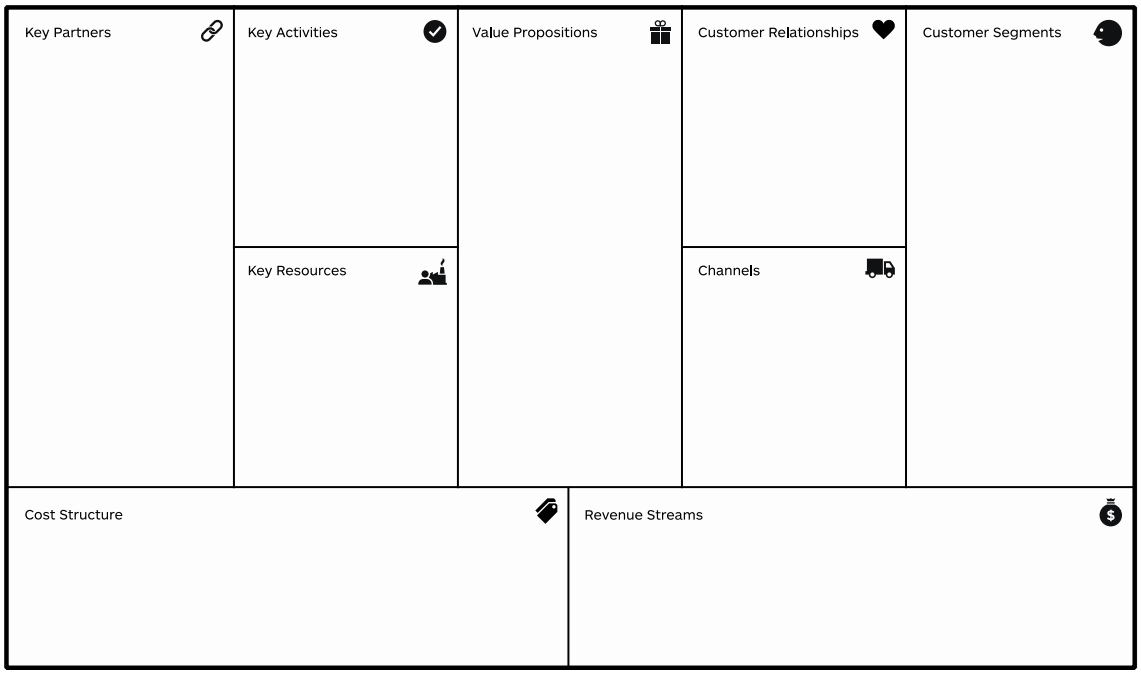

Figure 6: Business Model Canvas (Osterwalder et al., 2009, p. 44)

This visual way of plotting the Business Model shows the big picture, the roles in it as well as the interdependencies (Osterwalder et al., 2009, p. 50). Looking at the current business model and understanding its limitations can help in redesigning it in order to have a competitive advantage. This is especially important in the presence of a new technology such as blockchain. Applying the Business Model Canvas helps position the company, understanding the business model as it is today and develop a strategy guiding the company towards a future business model. Innovation is moved from the theoretical stage to the planning stage (Hemmer, 2016). The building blocks are then unbundled. “The concept of the “unbundled” corporation holds that there are three fundamentally different types of businesses: customer relationship businesses, product innovation businesses, and infrastructure businesses. Each type has different economic, competitive and cultural imperatives” (Osterwalder et al., 2009, p. 57). Innovations to value propositions, the operating model or the business system architecture could be resulting from unbundling the business model (Osterwalder et al., 2009, pp. 57–59).

Through the use of this technique, the areas that show potential for redevelopment can be identified and graphically illustrated, making it easier for companies to see where the current business model has limitations and deficiencies and how it could be improved.

4. Business model of property management companies

Experts expect that the blockchain technology opens up new business models in all industries that are in competition with other companies (Burgwinkel, 2016, p. 4). Therefore, the business model of property management companies will be looked at in order to identify processes that could be more efficient employing the blockchain technology. According to the innovation theory, this is an innovation-driven opportunity, driven by the technology blockchain. For the purpose of this thesis, the focus will be on the processes for rental apartments. The outlined service offerings and key activities of property management companies are therefore referring to property management companies operating in the rental apartment sector.

4.1 Service offering

As a first step, the services a property management company is offering will be looked at. The figure below shows an example of how the services of a property management company can be structured.

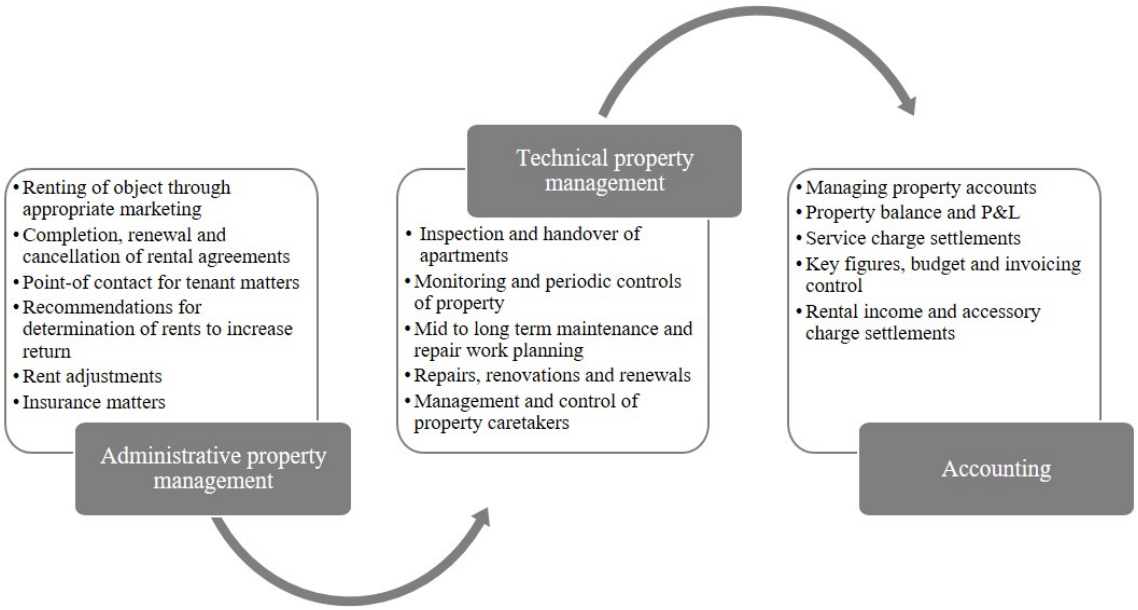

Figure 7: Service offering of a property management company (based on Verit's service offering "Immobilienbewirtschaftung," n.d.)

Property management companies are hired by the property owners to manage the property on their behalf. As such, they are given all the responsibilities concerning administrative property management, technical property management and accounting functions. The property managers are the point of contact for tenants facing a problem or needing to speak to someone but also for craftsmen and property caretakers.

4.2 Key activities of a property management company

Property management companies act in the interest of the property owner and are the point of contact for the tenant throughout the lifecycle of the tenancy duration – from marketing of the property and vacant apartments to acquiring and selecting tenants, creating the rental agreement, ensuring that the deposit payment has been paid, filling out the acceptance report and handing over the key. Once these steps are done, the property management company is responsible for any issues the tenant has, for the property maintenance and caretaking as well as the creation of accessory charge settlements for the tenants and property accounts for the owner in addition to rental adjustments. At the end of the tenancy duration, the property management company will take the apartment back, check for issues, make sure that the deposit is paid back and start looking for a new tenant. The following figure shows the key activities property management companies perform in a timeline.

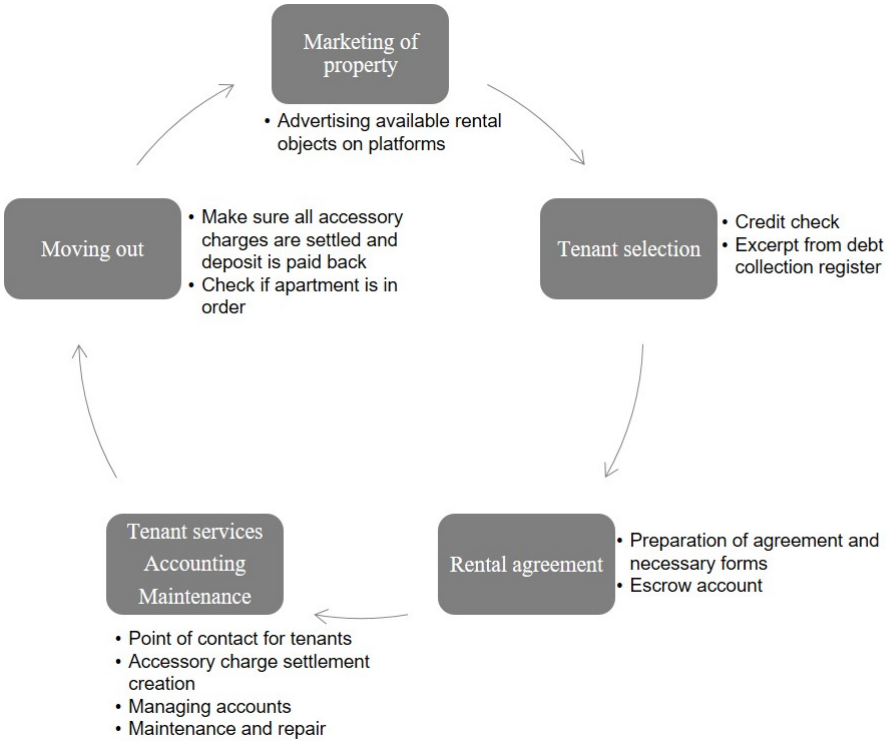

Figure 8: Key activities of property management company on a timeline

4.3 Business Model Canvas of property management company

To get a better picture of the business model of a property management company, the Business Model Canvas by Osterwalder will be employed in the following figure.

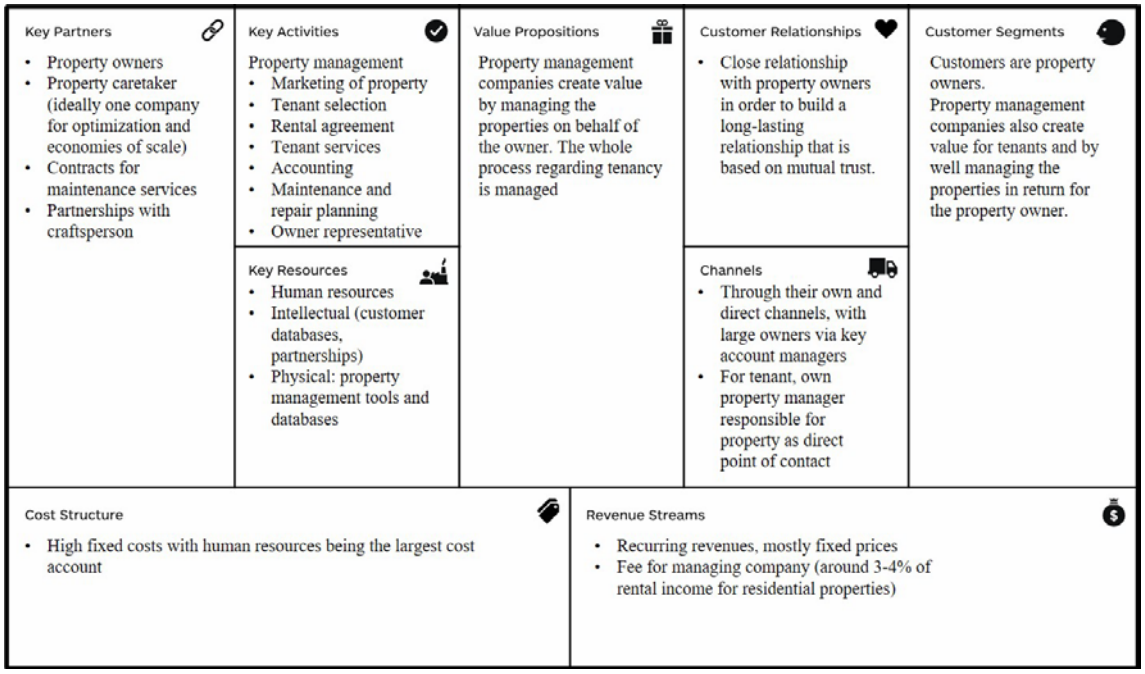

Figure 9: Business Model Canvas property management company (own content based on Osterwalder et al., 2009, p. 44)

Looking at the key activities, the marketing of the property currently is quite simple. A property is marketed via a platform such as Homegate and potential tenants can check these platforms. The tenant selection process requires credit checks and credit worthiness checks, however, tenants are required to provide the property management company with these documents, thus the current way could of course be automated but does not seem to be an issue. The rental agreement and especially the deposit payment are something that currently requires a lot of time and could be more efficient. Tenant services and especially being the point of contact for tenants is important and cannot be automated. The same goes for maintenance services, if something is not working properly, a craftsman needs to go to the property. Accounting functions and especially the accessory charge settlements are currently not the most efficient process within a property management company. Oftentimes, there are large time lags in the actual settlements and tenants wait for the actual invoice for quite some time. Therefore, from the key activities of a property management company, the rental agreement and accessory charge settlement processes seem to have the largest optimization potential. These two processes will thus be looked at more closely.

4.4 The rental agreement process

Once tenant and property management company agree on the terms and the tenant has received the acceptance, the property management company enters the data into their system manually. Many property management companies in Switzerland operate with a system called REM (Real Estate Management). The system promotes itself as being a modern application that covers all processes in the area of professional property management. The REM system will create a standard rental agreement based on the terms entered. The rental agreement will be checked and if necessary, adapted manually. As a next step, the rental agreement will be sent in duplicate by regular mail to the new tenant. At this stage, the property management company has not signed the contract, as they want to ensure that the tenant will actually sign. Together with the rental agreement, the following documents are sent to the tenant: 1) rental guarantee agreement for the bank, which is required to open up an escrow account. 2) In some cantons (e.g. Zurich), the official form containing the initial rent – statutory rent form – needs to be sent along with the contract. 3) Furthermore, a form to fill in how exactly the name should be inscribed at the door. In addition, a form for future tenants to fill in how they would like to pay rent: by direct debit, payment slip or standing order. Once all the forms are filled out and the tenant has signed the contract, all documents are sent back by regular mail to the property management company. At this stage, the tenant can start opening up an escrow account at the bank with the rental guarantee agreement received. The property management company checks the completeness of the documents including required signatures. If something is missing, the future tenant is called and forms or the contract is sent back. If everything is complete, the property management company countersigns the rental agreements and sends one version back by regular mail to the tenant. Additionally, the property management company has to give notice to the property caretaker, the power station EWZ and the resident's registration office that a new tenant is about to move in to the property. The tenancy can then be activated in the REM system, no longer showing a vacancy for that specific position and showing the new tenant and moving in date also in the generated tenancy schedule.

Once these steps are complete, the property management company needs to receive the confirmation that the deposit has been placed in an escrow account. Only after that can the apartment be handed over. For this, an appointment is made between the tenant and the property manager and the acceptance report is filled out, stating things that are not in order when the tenant moved in. The acceptance report is necessary, as the tenant does not want to be responsible for damages in the apartment that were already present. Only

after that are the keys handed over to the new tenant. The following figure illustrates the involved steps graphically.

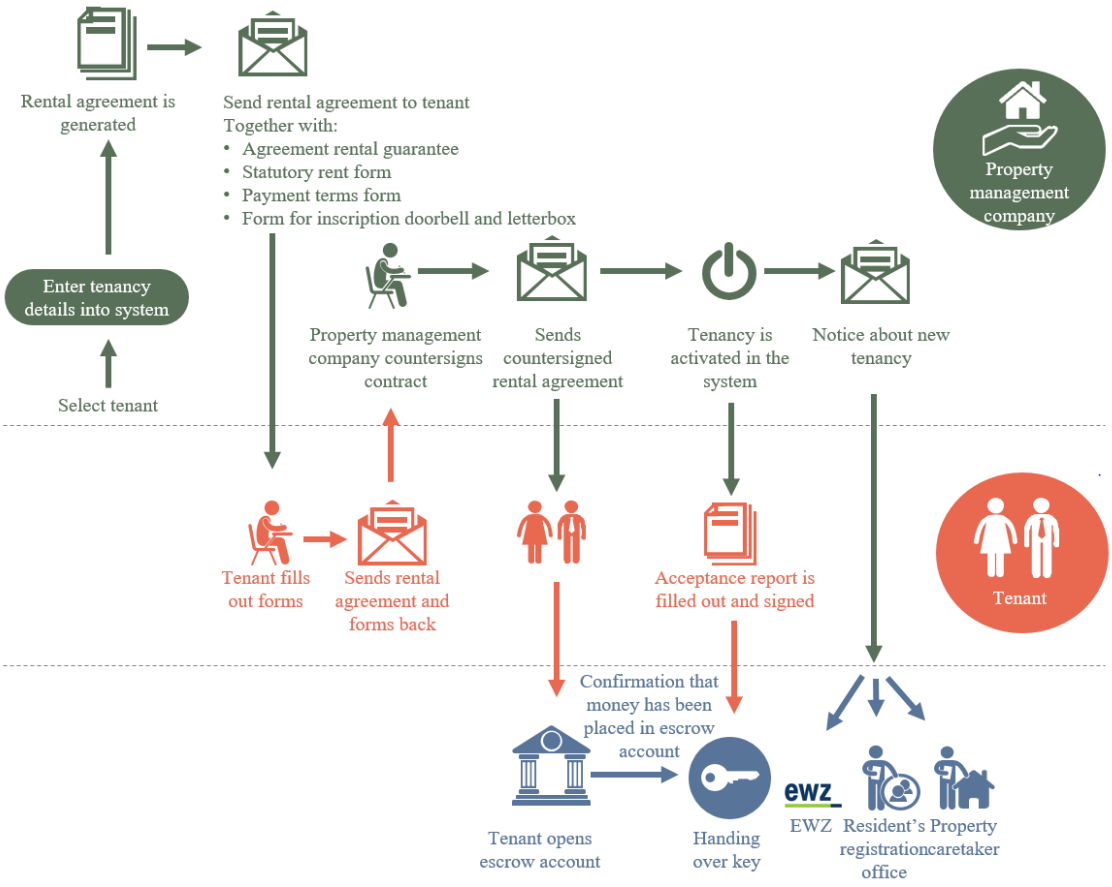

Figure 10: Process of rental agreement in the canton of Zurich (based on expert talks)

Legal side of the rental agreement

A rental agreement falls under the Swiss Code of Obligation (Obligationenrecht, OR). Art. 11 of the Swiss Code of Obligation (OR) from April 1, 2017, states that 1) "the validity of a contract is not subject to compliance with any particular form unless a particular form is prescribed by law." Art.1, paragraph 1 OR states that "the conclusion of a contract requires a mutual expression of intent by the parties". Therefore, a rental agreement does not need to be in a certain form and thus does not need to be written. A simple handshake is enough for a rental agreement to become valid. The relevant contract terms need to be agreed upon. For a rental agreement these would be contract parties, rental object, rental start date and rental amount (net rent and accessory charges). Thus, if a key is handed over, a tenant moves in and rent is paid, this is viewed as a contract by law, including all rights and obligations. In some cantons (e.g. Zurich, Zug, Geneva), the landlord is obliged to enclose a form to the rental contract informing the tenant about previous tenant's rent – the statutory rent form. Art. 253 OR defines a rental agreement as follows: "Leases are contracts in which a landlord or lessor grants a tenant or lessee the use of an

object in exchange for rent." Usually, rental agreements are, although not necessary by law, in a written form. This is especially due to the fact that in case of any disputes, the agreed upon terms are easily proven if a written rental agreement is signed by both parties. The rental agreement itself can thus be a form of proof in case of disputes. In general however, all terms that have not been agreed upon specifically, in written or verbal form, are governed by the Swiss Code of Obligation Art. 253 to 273c OR.

The current process is very time-consuming, especially due to the fact that the rental agreement is sent three times back and forth between the tenant and the property management company. Furthermore, the payment of the deposit is a time consuming process, as it involves different parties and each requires processing time. The most benefits could probably be achieved by making the process more efficient.

4.5 The accessory charge settlement process

To analyse this process, only costs that can be passed on to the tenant will be considered. They need to be mentioned in detail in the rental agreement and include charges such as heating, hot water and other operating costs. Accessory charges are usually paid monthly on account. Once a year, a detailed accessory charge settlement is created. The on account payments that have been made are subtracted and the difference is invoiced to the tenant. This can create mistrust, especially if tenants have to pay a large sum in addition to the on account charges. Currently, the property management company receives bills and all bills containing costs that can be passed on to tenants are scanned to an automatic accounts payable system and manually allocated to a property by the property management company. The automatic accounts payable system is able to learn over time and starts making suggestions for the allocation, however, the details are checked and if necessary adjusted manually. This includes costs for water, sewage, heating oil, electricity, property caretaking, service subscriptions for general maintenance services, chimney sweeping etc. Companies such as techem, Neo Vac or Rapp provide the property management company with the actual usage data of each tenant by reading the meters. The costs that are consumption-dependent such as heating and water are allocated to tenants according to usage based on the data and information received. For the settlement, the system takes all the information and automatically generates a total bill for the property. The total costs for each tenant are checked against the on account payments by the system. The on accounts payments are subtracted from the total invoicing amount and a bill is created for every tenant, only including the difference in costs, thus the amount that still needs to be paid. These bills are checked for correctness and completeness and if necessary, adjusted

manually. The bills are then sent to tenants by regular mail. If tenants don't believe that the bill is correct, they can ask the property management company for detailed information on each item and the property management company has to provide full details of the items charged. The process is summarized in the figure below.

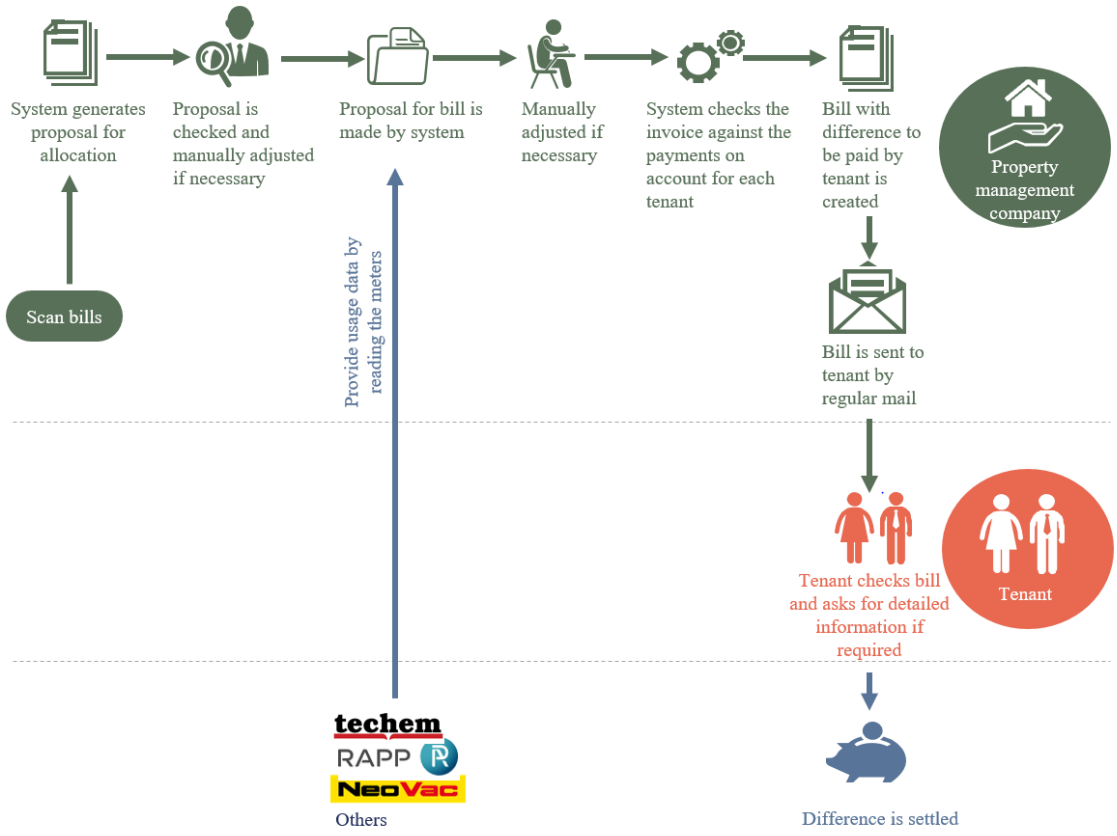

Figure 11: Process of accessory charge settlement (based on expert talks)

Legal side of accessory charges

The Swiss Code of Obligation governs general points of a rental agreement. Art. 257a, paragraphs 1 and 2 OR specifically govern the accessory charges: "Accessory charges are the consideration due for services provided by the landlord or lessor or a third party in connection with the use of the property". Furthermore "They are payable by the tenant or lessee only where this has been specifically agreed with the landlord or lessor." Accessory charges are defined in Art. 257b OR:

> "Accessory charges for residential and commercial premises are the actual outlays made by the landlord for services connected with the use of the property, such as heating, hot water and other operating costs, as well as public taxes arising from the use of the property."

And paragraph 2: “The landlord must allow the tenant on his request to inspect the documentation of such outlays”. The tenant thus has the right to look at the documentation of the accessory charges whenever the tenant decides to do so.

The current process is, similarly to the rental agreement process, time consuming and inefficient. Especially if the tenant would like to see the detailed information on the accessory charges, the process gets lengthy. Many of the steps and allocations of the costs to properties are still done manually. The process is thus prone to errors due to wrong allocation, which can lead to incorrect charges being passed on to tenants. This process could not only be made more efficient, but also more secure, transparent and reliable for tenants using blockchain technology.

4.6 Possibilities for blockchain technology in a property management company

The essential part of where the business model could be innovated is to bring the key activities to a blockchain, essentially handling everything from rental agreements to payment of rents, creating the property expense accounts to accessory charges. As for the use case of this thesis, the rental agreement process, from when the tenant is selected until the key is handed over (including the deposit payment) and the accessory charge settlement processes will be looked at. The potential for time savings and efficiency gains in these two processes seems to be rather large. As an example, when a rental agreement is created, it is sent back and forth for three times before it is signed by both parties and archived. The payment of the deposit again takes a few days until it has gone through. If everything is done in a very efficient manner, this process still requires at least one week, hindering the tenant moving in if the timeline is tight, especially because the escrow account needs to be opened by a bank. What some property management companies do to accelerate the process if the timeline is tight is that they offer the tenant to pay the deposit to the property management company and then open an escrow account for the tenant. This way, the tenant can already move in, as the opening of an escrow account would require another few days. Another process that currently is rather inefficient is the accessory charge settlement. According to experts, these settlements can lag behind for as much as three to five years, mostly however about one to two years. Furthermore, many mistakes happen due to the manual nature of cost allocation. If these processes could be rendered more efficient, transparent and secure, a lot of time and also effort could be saved. Having the rental agreements and accessory charge settlements on a blockchain will ensure that the data entered is correct and cannot be tampered with. This in turn will lead to less time-consuming checks of the rental schedule when further activities such as property

valuations are performed. Also, fewer tenants will want to look into the details of the accessory charges, again saving time and effort. Through ensuring that payments are settled via the blockchain, not only rents, but also expense accounts can all be interlinked. As tenants often do not trust the accessory charge settlements, especially when they are required to pay more than what they have paid on account, this issue of trust can be solved.

5. Blockchain use case for rental agreements and accessory charge settlements

5.1 Goal and purpose of the blockchain

The goal of this blockchain use case will be to make the process of signing a rental agreement including paying the deposit and the handling of accessory charges more efficient. The current process until the keys can actually be handed over to a new tenant is time consuming. The rental agreement is sent by regular mail three times between tenant and property management company. Opening an escrow account and making the deposit payment can also take a few days. This poses a problem especially when a tenant would like to move into the apartment in a matter of days. In the worst case, the move-in date needs to be postponed, leading to the loss of rental payments for this period of time. With the accessory charge settlement process, the bills and cost differences are settled on a yearly basis. There is information asymmetry in the settlements and issues of trust are involved. Through putting this process on the blockchain, integrity could be ensured and accessory charges could be settled immediately, weekly or monthly with actual consumption already factored in. Furthermore, the information asymmetry will be largely reduced, as tenants will have access to the information via their blockchain platform and can simply check why certain bills are higher than expected.

5.2 Basic functionality

5.2.1 Rental agreements

The future process of rental agreements including interactions with blockchain technology will first be outlined.

The property management company selects the tenant based on their criteria and the following terms are agreed upon and entered into the blockchain:

- Tenant
- Rental object
- Rental amount
- Start of tenant term
- Duration of lease (mostly for an unlimited period in the case of rental apartments)
- Possibilities for rental adjustments
- Accessory charges

The blockchain generates a rental agreement and automatically includes the required documents such as the statutory rent form, which is required by law in certain cantons such as Zurich. The doorbell inscription can be filled out by the tenant directly in the system. The form for the payment terms as well as the agreement for the rental guarantee for the bank are obsolete, as payments can automatically be triggered using smart contracts when certain pre-defined conditions are met. The tenant can check and approve the documents, the terms of the rental agreements and fill out the doorbell inscription form. Once done, a smart contract triggers automatic payment of the deposit amount to the property management company's wallet. As the property management company has already given consent by choosing that specific tenant, a counter-approval is not necessary and can be automatically triggered by the system. The rental unit including the new tenant is automatically activated in the system. The blockchain will automatically trigger that notices to the EWZ, the resident's registration office and property caretaker about the new tenant. As the deposit amount has been automatically transferred and all other necessary steps are also taken, the acceptance report can be filled out and the key for the apartment can be handed over.

Figure 12 is a graphic representation of the process as opposed to the current process.

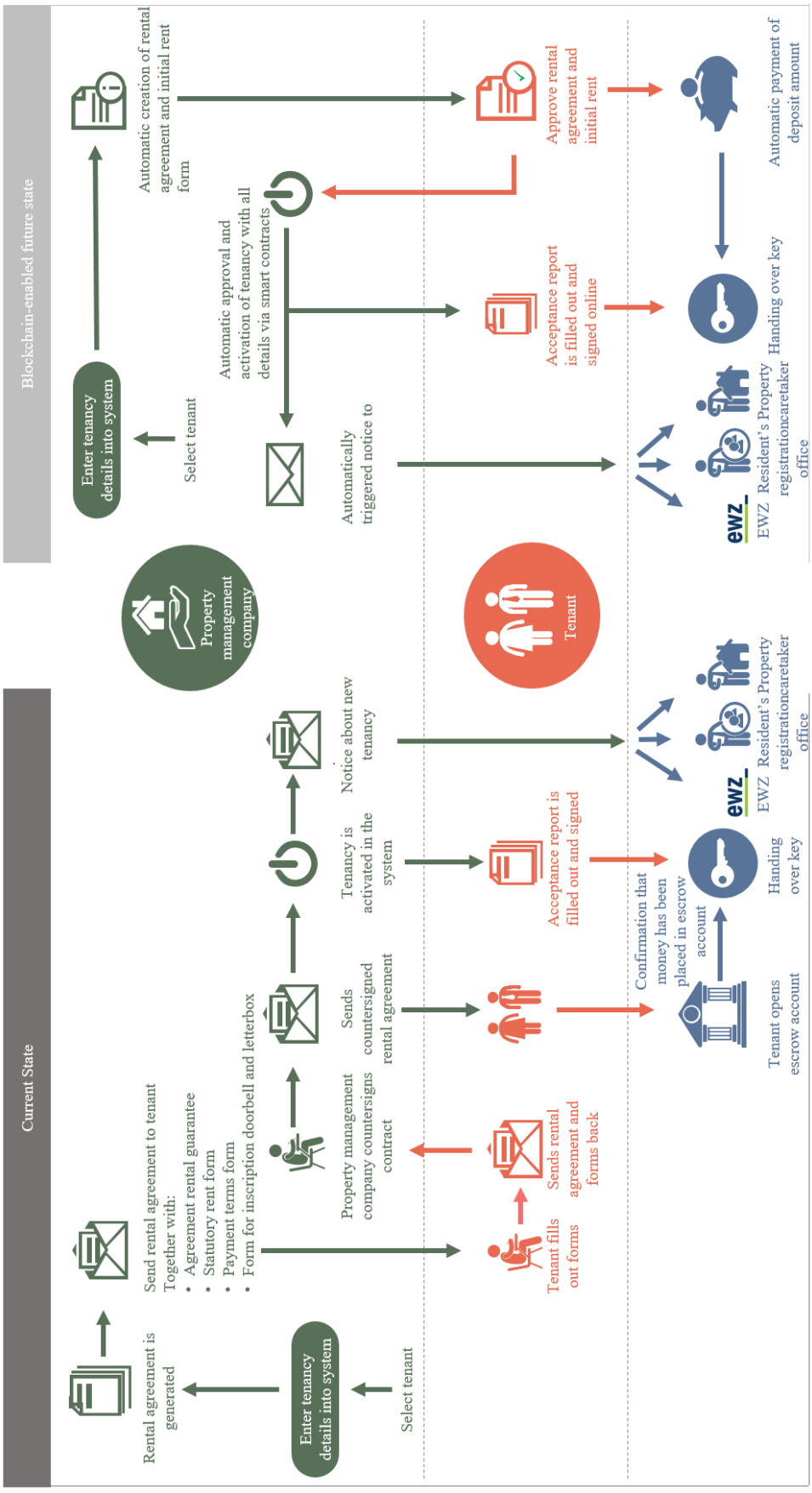

Figure 12: Current state vs. blockchain-enabled future state of rental agreement process in the canton of Zurich

A different representation of how the blockchain will work is shown below.

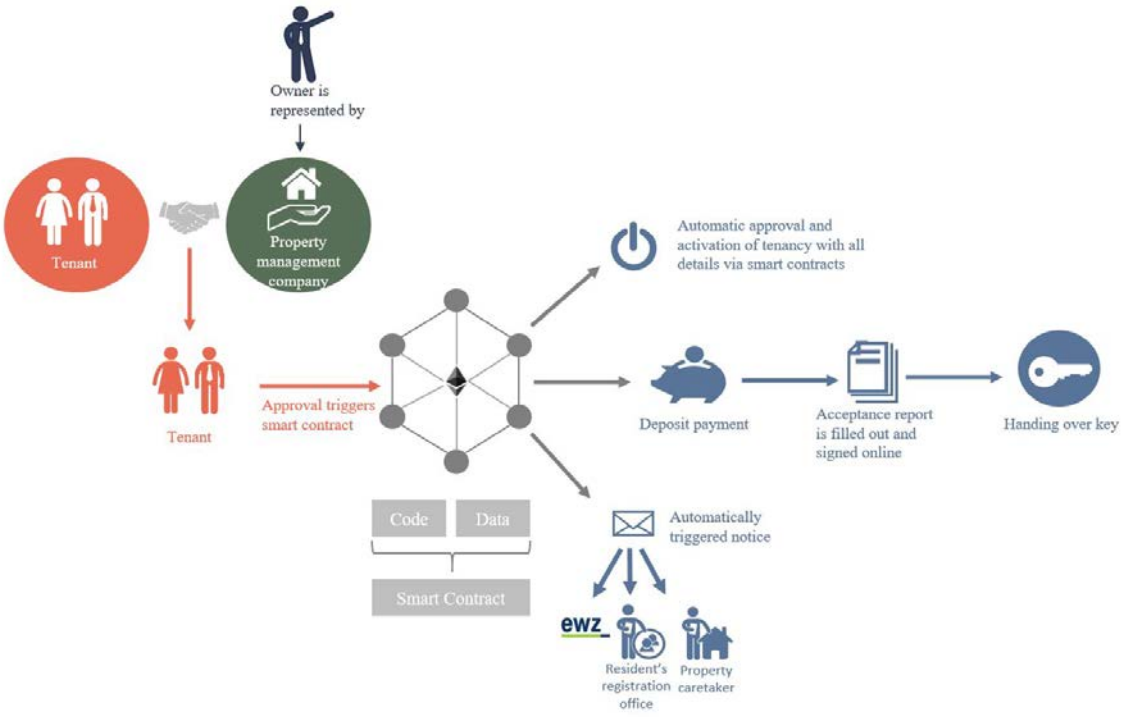

Figure 13: Rental agreement on a blockchain

5.2.2 Accessory charge settlements

As for the accessory charge settlements, the process will first be outlined as well, including interactions with the blockchain.

The property management company enters the details for the allocation of accessory charges as well as which costs are passed on to tenants in the distributed ledger. The blockchain can be connected to an oracle[1], an agent who is able to access external information and feed it into the blockchain. The oracle gets input from data providers such as NeoVac, Rapp, techem or others about the actual usage of water, electricity, etc. The blockchain can allocate the costs according to the mechanism defined by the property management company (for example per area, per actual usage or per apartment). Bills are generated and sent to the tenant for review. Once the tenant has reviewed the costs, automatic payment of accessory charges will be triggered and the accessory charges are settled.

[1] An oracle in a blockchain context refers to an agent that finds and verifies real-world occurrences. The agent submits the information to a blockchain, where it can be processed and used for smart contracts. As a blockchain cannot access data outside their network, a data feed like oracle is required to provide external data. Using external data, smart contract executions can be triggered when certain conditions are met. Examples can be weather temperature, price fluctuations, etc. (Voshmgir & Kalinov, 2017, p. 28)

Figure 14 is a graphic representation of the process as opposed to the current process.

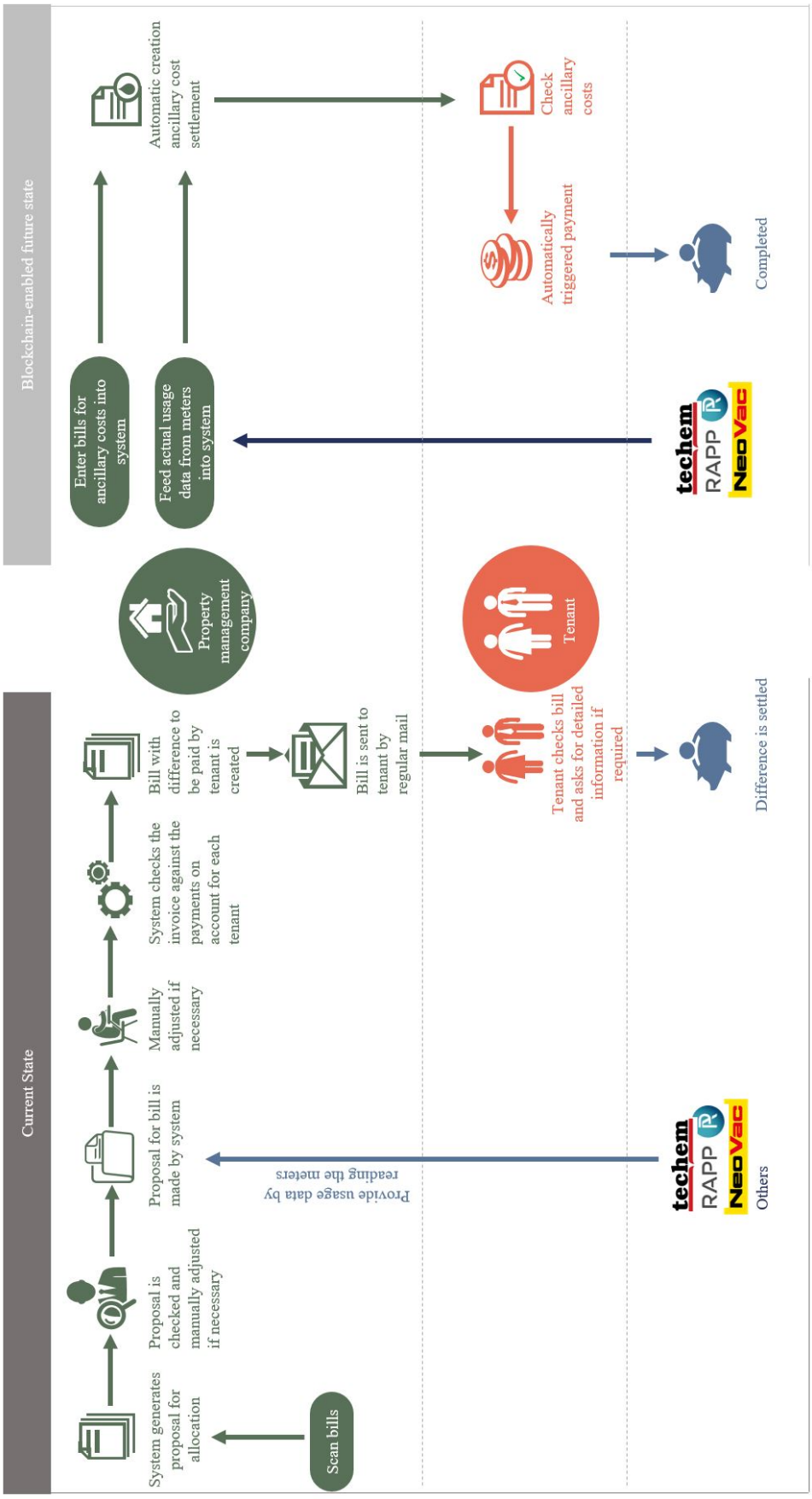

Figure 14: Current state vs. blockchain-enabled future state of the accessory charge settlement

A different representation of how the blockchain will work is shown below.

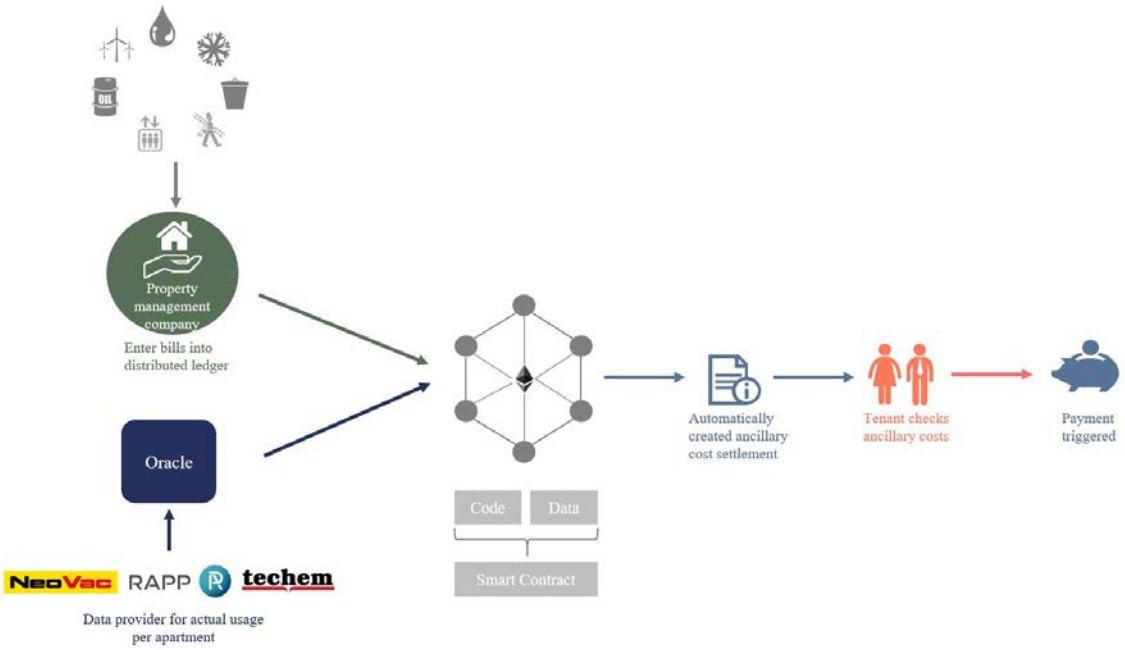

Figure 15: Accessory charge settlement on a blockchain

5.3 Model design and architecture

In order to develop a blockchain application, different aspects, criteria and requirements of the system need to be defined. It is important to outline which use case and business model the blockchain supports and what the users and operators of the blockchain will be.

The steps in the figure below are adapted from the steps outlined by Burgwinkel (2016) to build a blockchain application. These steps will be followed.

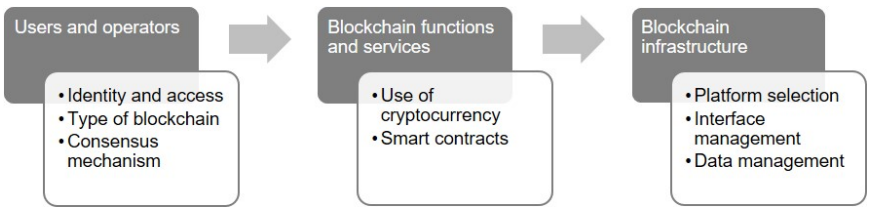

Figure 16: Overview of steps to build a blockchain application (based on Burgwinkel, 2016, p.30)

5.3.1 Users and operators

A key question of a blockchain application is, who the users will be and which benefits they can gain from participating in the blockchain network. The users of the blockchain will be the tenants as well as the property management company. Access could be granted to the property owners as well. The question arises, how the roles between the users, operators of the nodes and the organization are split. The roles can be either separate or

in form of a community model. In this case, it will make most sense to have separate roles, as tenants should not be able to actively participate in the operation of the blockchain and should further not be able to see all transactions occurring. Rather, tenants should have an individual user interface where they can approve and enable transactions. The management of the blockchain, including the feeding of data and definition and decisions regarding new applications should primarily be with the property management company.

Identity and access

In Switzerland, every building and every apartment has an official identification number. For a building, the unique number EGID (eidgenössischer Gebäudeidentifikator) refers to important data of the building including address, coordinates, year of construction, number of floors and what type of heating system the building has. For apartments, the unique identification number EWID (eidgenössischer Wohnungsidentifikator) refers to number of rooms and size of an apartment. Every person registered in the official register for residents needs to be linked to a unique building identification number as well as to a unique apartment identification number. As this data is already available, this number could be used and linked to the blockchain application in order to being able to clearly identify which apartment a person is renting. Thus, as a starting point for the model, it is suggested to enter the unique identification numbers of both, the buildings and the apartments into the distributed ledger. That way, a person entering a new tenant on the distributed ledger simply needs to choose the unique identification number of the apartment and add the tenant.

As this blockchain use case is limited to tenants, property management companies and property owners, it is important that the identity is known. Tenants must be identifiable to the property management companies and property owners, as they want to know with whom they are doing business. Legally, using a pseudonym should not pose a problem, as according to an article in the Schweizerische Juristen-Zeitung, academics partially hold the view that due to anonymity of the circumstances within a blockchain, there is no willingness to legally commit (von der Crone, Kessler, & Angstmann, 2018, p. 340). However, the anonymity does not contradict with the occurrence of the legal relationship. Only because the involved legal entities do not know each other's identity does not mean that they are not defined. Thus, the willingness to legally commit does not require the cognizance of the identity of the other party (von der Crone et al., 2018, p. 341). However, in practice, the property management company will want to know to whom they are renting

the apartment to. The tenants thus need to be able to provide a proof of identity. In the current process, the tenant needs to identify himself when applying for a new apartment with a copy of an identity card or passport. This could be done equally before the tenant is selected and the data could be entered in to the blockchain. Other options would be the use of the Swiss digital ID that is currently being developed under the name SwissDign Group AG by some of Switzerland's leading companies. The rental agreement itself does not require an official signature, as there is no form requirement by law. Only the notice for the cancellation needs to be written and sent with an official form, thus requiring an independent signature. Alternatively, a qualified electronic signature could be imaginable, which is, according to Art. 14 Abs. 2bis OR on equal terms with an independent signature. The requirements for a qualified electronic signature are regulated in the Federal Act on the electronic signature (ZertES). The electronic signature can only be executed with an authorized and regulated provider. However, due to the decentralized notion of a distributed ledger, a usage of a certified intermediary would be contrary to the system (von der Crone et al., 2018, p. 343).

Type of blockchain

As for the categories of access, differentiating between public, private and consortium blockchains, a consortium solution will make most sense in this case. It serves as a sort of extranet for participants, where all involved parties will be granted the rights to access the blockchain. A consortium blockchain is permissioned, as only selected participants are allowed to participate in the system. Defined participants have the rights to compute consensus algorithms and build applications or program smart contracts. These defined participants will be employees or management staff from the property management company. The property management company will also manage the rights and addition of new applications to the blockchain, if needed.

Consensus mechanism

As the software, which would be employed needs to permissioned, consensus algorithms different from Bitcoin's PoW might be more efficient. Instead of being distributed across thousands, the system can be concentrated in just a few nodes. In permissioned, consortium blockchains, consensus mechanisms such as voting or multi-party consensus are the ones making the most sense, also due to the fact that they use a lot less computing power and offer faster transactions.

5.3.2 Blockchain functions and services

Use of cryptocurrency

There are blockchains that function with or without the use of a cryptocurrency. Platforms such as Ethereum have their own currency, which makes reward payments to participants possible. The cryptocurrency can also be used to execute transactions between participants. Thus, cryptocurrencies can be used internally, for paying miners, but also for payments between participants. As for the context of rental agreements and rental payments, payments between participants should be enabled. Using a cryptocurrency enables better coordination in the process of payments. However, cryptocurrencies might be exposed to large currency fluctuations, therefore a solution for this problem needs to be found.

Smart contracts

Smart contracts are essential for the proposed use cases to work and definitely need to be empowered. The activation of the tenancy as well as the payment of rent and accessory charges will be working with the use of smart contracts and therefore this feature is necessary.

5.3.3 Blockchain Infrastructure

Platform selection

The architecture and design of the blockchain depends on the selected blockchain platform and the use case. Chapter 2.6 outlined the different blockchain platforms that could be employed, with the three most common ones being Bitcoin, Ethereum and Hyperledger. Bitcoin has been developed only for the purpose of the cryptocurrency Bitcoin and does not offer applications such as smart contracts. This platform can therefore not be used for the suggested use case, as smart contracts are required. A basic overview of the Ethereum and Hyperledger platform are provided in table 2.

	Ethereum	**Hyperledger Fabric**
Description of platform	Generic blockchain platform	Modular blockchain platform
Governance	Ethereum developers	Linux Foundation
Mode of operation	Permissionless, public or private[2]	Permissioned, private
Consensus	• Mining based on proof-of-work • Ledger level	• Broad understanding of consensus that allows multiple approaches • Transaction level
Smart contracts	Smart contract code (e.g. Solidity[3])	Smart contract code (e.g. Go, Java[4])
Currency	• Ether • Tokens via smart contract	• None • Currency and tokens via chaincode[5]

Table 2: Overview of blockchain platforms Ethereum and Hyperledger (based on Valenta & Sandner, 2017, p. 2)

Both platforms, Ethereum and Hyperledger have been developed to be used in multiple industries and both offer the possibility to employ smart contracts, which is required for the use case of rental agreements and accessory charge settlements. Ethereum is a permissionless blockchain, thus anyone can access it. However, few businesses will want to make their data public, which is why J.P. Morgan has developed Quorum, which is an enterprise-focused, permissioned version of Ethereum ("What is Quorum?," n.d.). Quorum has been designed with use cases within the financial services industry in mind, thus only the permissionless Ethereum platform will be looked at. Hyperledger is permissioned and private. This plays an important role as with Hyperledger, the operation is in a permissioned mode in any case, meaning that consensus is more fine-grained and encompasses the complete transaction flow – from proposing a transaction to the network until it is committed to the ledger. Nodes in the consensus reaching process can adopt different roles and tasks and the different roles can only see transactions and messages of the channel they are connected to (Valenta & Sandner, 2017, p. 4). In Ethereum on the other hand, the proof-of-work consensus mechanism is used, as it is permissionless and every node participating has equal roles and tasks (Valenta & Sandner, 2017, p. 3). The consensus mechanism is not specified in Hyperledger, various algorithms can be used as

[2] Ethereum is permissionless, however, Quorum has been built as enterprise Ethereum, which is a permissioned platform based on Ethereum.
[3] Solidity is a programming language for writing smart contracts that are run on Ethereum.
[4] Go and Java are programming languages.
[5] In Hyperledger, smart contracts are called chaincode, which is a program that can be written in Go or Java programming language.

a plug-in depending on the requirements. As Ethereum uses the proof-of-work consensus mechanism, it has a built-in currency that rewards nodes for mining called Ether. Hyperledger does not have a built-in currency, as consensus is not reached via mining. It does however offer the possibility to develop a native currency or digital token with smart contracts (chaincode) (Valenta & Sandner, 2017, pp. 2–7). To compare the two platforms for the specific use case of rental agreements and accessory charge settlements, the previously defined criteria that need to be fulfilled will be looked at for both platforms. The criteria, as a summary, are that separate roles need to be possible and identities known. Further, the blockchain platform should be permissioned, with a different consensus algorithm from PoW due to that. A cryptocurrency will be very beneficial as it enables rent, deposit and accessory charge payments directly. Furthermore, smart contracts are required. Table 3 summarizes the advantages and disadvantages.

	Ethereum	**Hyperledger Fabric**
Advantages	• Smart contracts written in contract-oriented language • Own cryptocurrency Ether	• Different roles and tasks possible • Confidential transactions possible (restricted access) • Permissioned network • Fine-grained control over consensus mechanism • Performance and scalability
Disadvantages	• Every node has equal roles and tasks • Every transaction is visible to everyone in the network • Permissionless • Proof-of-work consensus mechanism • Scalability and privacy due to permissionless mode of operation	• No built-in cryptocurrency • Lack of proven use cases • Potentially large maintenance costs • Might not be as secure as a public blockchain due to different consensus mechanisms

Table 3: Advantages and disadvantages of Ethereum and Hyperledger platform (based on Valenta & Sandner, 2017, p. 2)

In regards to the defined criteria and looking at the advantages and disadvantages the two platforms are offering, the Hyperledger platform might be more suitable for the suggested use cases. Hyperledger offers the possibility to define different roles and tasks to tenants,

owners and the property management company. Identities are known and only defined nodes can validate transactions based on the consensus mechanism chosen. Although Hyperledger does not have a built-in cryptocurrency but it offers the possibility to have a currency or tokens. Ethereum on the other hand does not fulfil the defined criteria especially due to its permissionless mode of operation and the fact that roles and tasks are identical for all participants.

Interface Management

Interfaces with other systems of the property management companies need to be clearly managed and work effortlessly in order for an actual implementation to be realistic. The interface management will however not be looked at in more detail for the purpose of this thesis.

Data management

Data sets can be saved on-chain or off-chain. In the case of off-chain data saving, a reference to the external data will be saved on the blockchain. Having the entire data set on the blockchain is possible if the blockchain can handle the size of the data. If the data is of large size, part of the data can be externally saved and references to the external data can be entered in the blockchain. In the case of rental agreements and accessory charges, it will make sense to have the data saved on-chain entirely. It is though important to define read- and write-rights and allocate those rights to the participants of the blockchain. The tenants should only have read-rights for the cost settlements and their own rental agreement. Additionally, they should be able to approve the rental agreement in the beginning and release the payment of rent and accessory charges. This goes together with the visibility of the data in the blockchain, as of course the visibility of all data should also be limited to the property management company and tenants and property owners should only see their specific documents.

6. Analysis

To test the use cases, expert interviews were held in the form of semi-structured interviews with experts from property owners, property management companies and real estate advisors. Five interviews in total were held in July and August 2018. The interview questions were oriented along specific guideline questions and were used to analyse the feasibility and implementation of the defined use cases. Due to the semi-structured nature, questions were slightly adjusted depending on the interviewees' answers. The first part of the interviews contained general questions about the rental agreement and the accessory charge settlement processes and were used to find out in what ways these processes could be improved. Furthermore, general questions about blockchain technology were asked to find out if companies are already thinking about potential use cases. In the second part, the two models were shown to the experts with the as-is and the blockchain-enabled future-state and experts were asked questions about the use cases. Besides the general description of how the interview will be structured, no information was given to the experts prior to the interview. Due to confidentiality reasons as well as the fact that the interviews were held in German, the transcribed interviews will not be published and the experts will remain anonymous. If the answers varied, differences in property owners, property management companies and real estate advisors will be outlined. If answers were similar, the three categories will not be distinguished.

6.1 Current processes

Overall, one can conclude that property management companies receive a large amount of freedom from property owners regarding the accessory charge settlement and a little less for the rental agreement. Furthermore, large property owners seem to be more involved in the processes than small owners. Thus essentially, the property management companies can decide on the accessory charge settlement process but need to talk to the property owner to make sure that the standard rental agreements are in an appropriate manner.

6.1.1 Rental agreement process

Experts were asked where they see potential to improve the current rental agreement process. Experts agreed that the process is currently time-consuming, especially since many things are still sent via regular mail. Many tasks are still performed manually, and one representative of a property management company sees the potential to automate approximately 80% of the process. For one expert, the vision is that a tenant can write his own

rental agreement. Especially the deposit payment process was mentioned to be very inefficient and time-consuming. The actual handling time of the rental agreement process does however not seem to pose an issue to the property management companies.

Regarding document storage, currently a lot of documents are still on paper, and even if received electronically, printed out and filed. However, some of the experts are already working on solutions to have a central and digital database for documents.

6.1.2 Accessory charge settlement

Again, experts were asked whether they see potential to improve the current process. They all agree that the current process is inefficient and usually lags behind. The process, according to a representative of a property owner, currently is unstructured, not efficient and many mistakes happen. One expert mentioned that about 90% of the settlements contain mistakes and about 30% of the work is wasted as people are not careful enough with the allocation of costs. Another issue with the current process is that the allocation key is not clearly defined and differs from property to property, owner to owner as well as canton to canton.

6.2 Examination of blockchain technology

Out of the five experts, four are looking at different technologies and have some ideas, but are not concretely working on a blockchain project. Only one expert said that they are concretely thinking about how to integrate blockchain technology in their current processes. Experts were asked about which potential use cases they see and the table below summarizes the answers.

Potential use cases	
Expert 1	-Have documents stored centrally for all involved parties throughout the lifecycle of a property -Deposit payments
Expert 2	-Lifecycle Property DNA measuring state and condition of building
Expert 3	-Deposit payments and rental agreements -End-to-end processes
Expert 4	-Rental agreements -Framework agreements with providers and automatic handling of those -Cross-reference energy bills from utility companies with own data and if e.g. +/-3% within same range automatically process payments
Expert 5	-Creation of rental agreements -Land registry, although still many legal hurdles

Table 4: Summary of expert interviews for potential use cases

Especially expert 4 has a vision of having digital framework agreements with providers and if it has a heating system from a certain provider, it is automatically added to the framework agreement and included in the maintenance of the provider. Furthermore, depending on which heating system, the amount for the yearly maintenance is automatically added to the budget and if the bill arrives, it can be automatically processed if the amount is the same. Another vision of expert 4 is to cross-reference energy bills and usage meter data with their own data and if it is within a certain range, i.e. +/-3% difference, it is automatically processed. What can be derived from the interviews is that people are working on digitalized solutions and end-to-end processes, however, they are often unsure whether this can already be called blockchain or if it could be solved with a different technology. Expert 2 has ideas and has worked on the topic of blockchain in the past, however, sees too much potential in the portfolio itself and the focus currently lies on investment planning and activating the operative opportunities within the portfolio before considering new technologies.

6.3 Changes to business model of property management companies

Experts from property management companies were asked if they believe that the business model of property management companies will change with new technologies such as blockchain. Two of the three believe that departments will become more specialized and people will be working more as exception handlers, as many of the repetitive and standardized tasks can be automated. One expert believes that the job description will become broader and more interesting due to a wider work catalogue. However, none of the experts mentioned that the work will become entirely different or that they believe that the service offering will become much larger.

6.4 Proposed use case

Experts were shown the models of the two use cases for the rental agreement and accessory charge settlement as proposed in chapter 5.2 and were asked what they think of the model and potential advantages and disadvantages they see. One expert did only focus on the rental agreement process and one expert only focused on the accessory charge settlement process. The other three experts focused on both use cases.

The table below summarizes the advantages and disadvantages experts see in the proposed models.

Use case – rental agreement and accessory charge settlement		
Interview partner	Advantages	Disadvantages
Expert 1	-Transparency -Automatization -Efficiency	-Cryptocurrency fluctuations -Accessory charge settlement process not really feasible due to interdependencies -Legal insecurities -Security and hacking
Expert 2	-Uniform process not influenced by humans -Structured data quality -Standardized	-Might lead to fewer plausibility checks as people rely on system -System works as programmed -Legal compliance needs to be ensured -Human as such still important in property management -Data quality in the system
Expert 3	-Time saving -Less prone to errors -Centrally stored documents -Traceable -Transparent	-Accessory charges include many interdependencies from other parties -Legal compliance -Cryptocurrency fluctuations -Should be end-to-end and fully integrated
Expert 4	-Increased efficiency -Increased quality -Faster information flow -Benchmarking possible due to structure and standards	-Data quality in the system -Question if it adds value for small multi-family house
Expert 5	-Increased efficiency -Digitalized processes	-Overwrite rules will be necessary -Exceptions to policies need to be defined -Flexibility needs to be large enough -Works as programmed -Data protection

Table 5: Summary of expert interviews for advantages/disadvantages of the proposed use cases

To provide a deeper examination of their answers, both use cases will be looked at and the answers will be summarized.

Rental agreement process

For this process, experts generally agree that it could be digitally solved, they are not sure if it necessarily needs to be with a blockchain solution. Furthermore, the process looked at, after the tenant is selected, although it looks rather inefficient, doesn't seem to bother property management companies too much. Experts are rather concerned with the tenant selection process as this is much more time consuming. However, especially representatives from property owners mentioned that it would be an advantage if the process could be rendered more efficient. Three out of the five experts see legal compliance as one of the main disadvantages as currently there is no clear solution regarding digital signatures.

However, as mentioned in chapter 4.4, a rental agreement according to the Swiss Code of Obligation has no form requirement and thus digitally approving the contract would be enough to be able to prove what terms have been agreed upon between the two parties. Tenant notices for cancellations as well as rental adjustments however need to be in a written form, including official forms and there is where the problem with the signatures arises. What was also pointed out as a disadvantage is the fluctuation risk of cryptocurrencies. Neither property owners nor property management companies would want to carry that risk. Furthermore, the system works as programmed, which is seen as somewhat of a disadvantage by two experts and it needs to allow a certain flexibility, if this is necessary for specific cases. The issue would be that if for example the process of tenant selection is also integrated and the system is programmed to choose the best-fitting tenant, people with an entry in the debt collection registry will have no chance of finding an apartment, no matter what the entry is for.

Accessory charge settlement process

What was mainly mentioned for this process is that the current process is largely inefficient and is often lagging behind sufficiently. Due to the interdependencies from providers, some issues cannot be solved without their collaboration. It was mentioned by the experts that some bills are monthly, some quarterly, some yearly, thus settling bills monthly instead of on account payments is not seen as feasible. What is considered as an advantage is that the system would be transparent and tenants could check what costs they have been charged with and don't need to look at the documents at the property management company anymore. The allocation key is what is most important, as this needs to be clearly defined. The biggest issue is in the definition of this key, as depending on the canton and owner, different costs are passed on to tenants. Once the allocation key is defined, the accessory charge settlement could be created automatically. However, before the issues regarding the different timelines of the providers in sending their bills is resolved, payments on account will still be necessary and accessory charges could still be settled once a year only. This would still increase efficiency as the transparency is increased and the process might not be lagging behind as much.

6.5 Tenant acceptance

Experts believe that most of the tenants will accept a solution like the one suggested if the application is simple, easy to use and intuitive. The estimate of two of the experts is that roughly 90% of tenants will accept the proposed use cases. For the remaining tenants, which might not be digitally agile or have language barriers, the proposed use cases might

not be acceptable and as they don't want to exclude certain tenant groups, a different solution would be needed for these tenants.

It can be concluded that already now, a large percentage of tenants would accept the proposed solution. For the remaining tenants, which are approximately 10%, a different solution might need to be offered. However, over time, the proposed solution will be accepted by all tenants.

6.6 Implementation of the use cases

All of the experts believe that there will be changes with digitalization. Experts do seem to be rather cautious about a full automation of processes though, especially when no personal contact is necessary. One expert mentioned that this might be feasible for short-term stays such as an Airbnb, where even the keys would no longer be required and tenants could simply rent the apartment, open the door with an application on their mobile phone once the bill is settled, stay at the apartment for the agreed upon period and then leave. By leaving and locking the door, a message could be sent to a cleaning team, the apartment cleaned and prepared for the next tenant. With this full automation, no personal contact would be necessary, as even if the property has some technical fault or something is not working properly, an application could be used and the necessary craftsperson mobilized. Further, modern properties could even generate a fault report automatically if for example the central heating is not functioning properly and trigger automatic mobilization of a craftsperson. However, for longer term rental apartments, tenants will want to have some sort of personal contact, at least for the next few decades.

For an actual implementation of a blockchain solution, the system needs to establish itself further and the insecurities regarding legal issues, cryptocurrency fluctuations and data quality need to be solved. Experts generally believe that it will take some years, but then, integrated solutions with end-to-end processes will become standards, although they are not sure that it necessarily has to be in a blockchain. It cannot be clearly stated whether property owners will be willing to invest in these use cases, as the benefit lies mostly with the property management company. One property owner representative would be willing to invest if the fee paid to the property management company can be lowered and the other property owner representative doesn't see the investment as the owner's responsibility. Property management companies and real estate advisors believe that they will need to invest in the automatization and standardization of processes. They are not sure whether the investment will pay off, but definitely believe that investments will be necessary.

Experts were asked what would be required to ensure utilization. The answers were not uniform. Two experts mentioned that it requires a simple handling, another expert mentioned that data quality needs to be good, it needs to be a standardized software that can be integrated as a standalone and that the implementation should be possible without large investments. The last two experts mentioned that the interfaces need to work and the processes need to be fully integrated. It needs to be payable, the benefits derived need to be in line with the costs incurred

7. Conclusion and outlook

With the proposed blockchain use cases, a potential solution for the currently rather inefficient processes of rental agreements and accessory charge settlements was developed. Due to the permissioned setting and the pre-defined nodes participating in validating in transaction, it is controversial that the proposed use case can be called a blockchain as many features of an open-source, public and fully decentralized blockchain will not be employed.

With the help of the expert interviews, an assessment of the prospects of a realization was analysed. Not all property owners are willing to participate in investing, as they believe that other stakeholders will then profit from their investment and that the process and responsibility essentially lies with the property management companies. In order for property management companies to make the necessary investments for a potential implementation however, they need to see that the investment pays off. Furthermore, it is believed that the technology requires further development and that actual implementation use cases need to happen for them to have a proof of concept before they would start thinking about an implementation. Experts believe that things will change and that processes will be end-to-end, fully integrated and digitalized, but not necessarily with a blockchain solution.

The rental agreement process is definitely an area where experts see potential, given that legal compliance is ensured. It will make the current process more efficient, more transparent and also traceable. However, what is worth mentioning is that the process of the rental agreement and signature itself is not something that they generally consider to be inefficient. Although the process takes quite some time due to the sending back and forth via regular mail, the actual handling time is not something that seems to be an issue. This process would be most beneficial if the on-boarding, meaning the tenant selection process including the contract could be automated. However, this of course carries the danger that the tenant selection process will become very rigid, with pre-defined rules in the system

not allowing for deviations. The focus will be much more on the income and a clear extract from debt collection registry rather than if the person actually is a fit for the specific rental object. They do see large potential in automating the deposit payment process.

For the accessory charge settlements, opinions differ a bit. There are many interdependencies with providers and many different stakeholders involved. Furthermore, not all properties have the necessary technology to measure usage data yet. This process is currently very inefficient and a lot of time could be saved by automating the process, thus experts would see a large benefit in automating this process. The most challenging aspect however is the framework for the allocation of costs. There are many different solutions and also many grey areas around the topic of which costs can be passed on to the tenants. In order to being able to clearly define allocation keys in a system and create accessory charge settlements at the push of a button, the allocation issue needs to be resolved and a framework should be developed with guidelines how costs can be allocated to tenants. Furthermore, property management companies not only rely on their processes and data, but also need input from providers regarding the costs for electricity, water, heating and so on. As the providers differ in how they settle bills, from quarterly, to semi-annually, to annually, no clear date can be specified regarding when to generate the accessory charge settlement.

As a conclusion, both cases seem to be feasible and would result in time savings and efficiency gains. However, the accessory charge settlement process will definitely require other stakeholders to reconsider their current way of doing business, as the problem not only seems to lie with the property management companies but also with the providers who need to send the invoices before they can be further processed by the property management company. Furthermore, the allocation key for which costs are passed on to tenants needs to be clearly defined before it can be entered into a system. With the rental agreements, the legal situation needs to be fully compliant. Although legally, no signature is required for the rental agreement, stakeholders need to be ensured that an online approval does hold in case of a legal dispute in order to fully trust the proposed solution.

For a deeper analysis of the suggested use cases, a pilot project would need to be started for a potential implementation.

Outlook

As a future outlook, the full integration of the on-boarding and off-boarding process of tenants as just described above is something that could be analysed and looked at for short-term or for long-term rental apartments. For longer term rental apartments, using blockchain already for the tenant selection process until the moving out, including paying back the deposit. Rent adjustments could be triggered through smart contracts, indicating how rents are adjusted if the reference interest rate changes. An oracle could access the data from the Federal Bureau of Housing (Bundesamt für Wohnungswesen) quarterly and a smart contract could trigger automatic rent adjustments if the pre-defined condition of a change in the reference interest rate is met. Accessory charge settlements and rents can be paid automatically and effectively, no paper work would be necessary anymore. For this to happen however, the current laws will need to be reviewed and adapted, as the cancellation of the rental agreement as well as the rent adjustments currently need to be in a written form including the use of an official form and require an official signature. If this however was ensured, the fully integrated process of the key activities of a property management company on a blockchain would be very efficient, transparent and traceable. The data could be further processed and for example used for property valuations or in transactions, as all the data is in a form that is secure and transparent.

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Appendix

Guideline for interview questions

Please note that the interviews were held in German. The following questions have been translated to English in order to match the content of this thesis.

Questions for property owners

1. How much are you as a property owner involved in the rental agreement and accessory charge settlement process?

Rental agreement process

2. Do you think that the current process could be improved?
3. Which documents are important for you as an owner and how would you like these to be available?

Accessory charge settlement process

4. Do you think that the current process could be improved?
5. Which documents are important for you as an owner and how would you like these to be available?

Blockchain

6. Is blockchain technology a topic of interest in your company?
7. Where do you see potential use cases?

The developed use cases were shown to the experts at this stage and the as-is and blockchain-enabled future state was explained before asking the next questions. Those questions are referring to both use cases.

1. Which 2-3 biggest advantages do you see in the proposed use case compared to the current process?
2. Which 2-3 biggest disadvantages/challenges do you see in the proposed use case compared to the current process?
3. How much time or costs do you think could be saved?
4. Where do you see potential to improve the proposed use cases in regards to your daily business?
5. Would you make the necessary investments to implement such a use case?
6. How realistic do you think the implementation of these use cases is?

7. What does need to be fulfilled in the proposed use case that the usage for you as a property owner is ensured?
8. Do you think tenants will accept the proposed use cases?

Questions for property management companies and real estate advisors

1. How much freedom do you as a property management company receive by the owners in the rental agreement and accessory charge settlement processes?

Rental agreement process

2. Do you think that the current process could be improved?
3. Which documents are important for you as an owner and how would you like these to be available?

Accessory charge settlement process

4. Do you think that the current process could be improved?
5. Which documents are important for you as an owner and how would you like these to be available?

Blockchain

6. Is blockchain technology a topic of interest in your company?
7. Where do you see potential use cases?
8. How do you think will the property management business change in regards to new technological developments?

The developed use cases were shown to the experts at this stage and the as-is and blockchain-enabled future state was explained before asking the next questions. Those questions are referring to both use cases.

9. Which 2-3 biggest advantages do you see in the proposed use case compared to the current process?
10. Which 2-3 biggest disadvantages/challenges do you see in the proposed use case compared to the current process?
11. How much time or costs do you think could be saved?
12. Where do you see potential to improve the proposed use cases in regards to your daily business?
13. Would you make the necessary investments to implement such a use case?

14. How realistic do you think the implementation of these use cases is?
15. What does need to be fulfilled in the proposed use case that the usage for you as a property manager is ensured?
16. Do you think tenants will accept the proposed use cases?

Declaration of Honour

I hereby assure that I personally prepared the present academic work on the topic of *A use case of blockchain technology in the real estate industry for the rental agreement and accessory charge settlement processes* and confirm that I have used no resources other than the ones declared. Every part of this Thesis that has been cited literally or analogously from published or unpublished works has been clearly indicated in each case through the indication of its source (including secondary literature).

This Thesis has not been presented in this or any similar form to any other examination Committee and has not been published so far.

Zurich, September 3, 2018

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Livia Verena Wetzel