Blockchain in office building transactions

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Award date:
2019

EINDHOVEN UNIVERSITY OF TECHNOLOGY

Department of the Built Environment (BE),
Industrial Engineering & Innovation Sciences (IE&IS)
Master Construction Management and Engineering

Blockchain in office building transactions

Master Thesis

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Final version

Amsterdam, Tuesday 12th February, 2019

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Title
Blockchain in office building transactions

A design science research towards the implementation of blockchain technology in the transaction process of an office building.

Master Thesis

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"The best way to predict the future, is to create it."

- Abraham Lincoln

Preface

*Where everything started '**Zuidhorn**', Groningen.*

Once my hometown, but also the first municipality in the Netherlands to introduce a blockchain application ('*Het Kindpakket*'), or at least they thought it was blockchain. Zuidhorn is no exception. Up to 80% of the initial coin offerings conducted in 2017 were scams (Satis Group LLC, 2018). Blockchain is a *buzz* word, a *hype*, with an underlying technology that is interesting, but much of enthusiasm for this technology is because people lack of knowledge and incomprehension of the technology.

'Blockchain technology – the solution for everything, but what is the problem?'

Although recent studies have examined the possibilities of applying blockchain technology, applications remain unclear. In this research, blockchain technology is proposed as a solution for the problem: *how to improve the transaction process of an office building.* It aims to identify the challenges currently faced, and suggests how blockchain technology can solve them.

Plenty of people contributed to and supported the writing of this thesis. Firstly, I would like to offer my gratitude to Frank Kerstens and Ruud Boots for keeping me on track during the writing of my thesis. Pursuing my ideas freely and giving advice form a business perspective, was very helpful. Also, I would like to thank my graduation buddy Dagmar Bokkinga for the writing days.

Additionally, I would like to offer my gratitude towards my TU/e supervisors Bauke de Vries and Raymond Opdenakkker, for giving advice and support from an academic perspective on a topic which is not very common within scientific research and the faculty of Construction Management & Engineering. Without them, it would have been a lot more difficult to complete this thesis.

Last, but definitely not least, at a personal level, I would like to thank my parents and brothers – Ton, Ineke, Wijnand and Lodewijk Wouda – and in especially my girlfriend Diede, for their support and motivation throughout my study and research. Looking back on the past couple of years, this master thesis has formed a nice ending for my time as a student!

I hope reading this report is interesting and inspires you towards the implementation of blockchain technology in the real estate sector.

Hugo Wouda
February 2019, Amsterdam

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Management summary

Technology advances, such as blockchain, are transforming markets across the globe, including the commercial real estate sector. Transactions in this sector are known to be time consuming and inefficient, in part due to the lack of market transparency. This research focuses on the development of a blockchain application that can enhance the transaction process of office buildings in the Netherlands.

Due to the commercial real estate (CRE) markets' fundamental characteristics – heterogeneity and immobility – real estate transactions face the joint challenges of information inefficiencies and corresponding high transaction costs (Ling and Archer, 2012). Noteworthy is the traditional role of banks within the real estate transaction market. Financing CRE is usually done through lending from banks (60% - 70% LTV) (Gout, 2017, p. 82). However, due to technology advancements, changing client demand and stricter regulation (Basel III and Basel IV), the traditional role of banks is under pressure (Deloitte, 2018). In this context, for banks to stay relevant, current (internal) processes and new business model 'enablers' should be researched.

Although recent studies have examined the possibilities of applying blockchain technology, applications remain unclear (Dijkstra, 2017; Seuren, 2018; Veuger, 2017). All studies indicate that blockchain technology could lead to improvements in efficiency, transparency and therefore trust. Additionally, banks could use blockchain to better understand the risks associated with real estate and streamline internal processes (Dijkstra, 2017; Deloitte, 2017). This research focuses on an infrastructure for a blockchain-based application to improve the current way real estate is transacted by introducing a more comprehensive, better quality and more complete asset information overview, which may payoff for all involved parties (including new business model 'enablers') and could potentially increase the size of managed global real estate.

The transaction process of an office building is divided into multiple stages (Crosby and McAllister, 2015; Dijkstra, 2017; Hordijk and Teuben, 2008; Just and Stapenhorst, 2018): preparation, marketing & pre- due diligence, due diligence and completion. Currently, due diligence phases and negotiations are carried out to verify and validate information. These processes are a key indicator of the lack of transparency and perceived unreliability of the data used in the transaction process. Furthermore, the decentralized way of working with various 'non-digitized' documents makes the process complex and unstructured.

To support this complexity, semi-structured interviews were conducted to identify and map pain points to specific phases and tasks in the transaction process. All interviewees indicated that pain points mainly occur during the due diligence and completion phases and are related to *data structure* and *data quality*. However, pain points are formed during the preparation phase in the transaction process and the management of the real estate once the property has been acquired. Implementing new technologies, such as blockchain, could lead to an improvement in the transaction of an office building in the future.

A blockchain distributed ledger is simply a new way of managing data and consists of five core elements (Hileman and Rauchs, 2017; Seuren, 2018; Swan, 2015; Tapscott and Tapscott, 2016; Tasca et al., 2017): Cryptography, Peer-to-peer (P2P) network, Validity rules, Consensus mechanism

and Ledger. Blockchain and its deriving applications, e.g. smart contracts (Blockchain 2.0) and applications (Blockchain 3.0), could support and enhance the reliability, efficiency and security of data transferred among a network (Swan, 2015, p. ix). Therefore, blockchain technology features seem to provide a solution that could enhance the transaction of office buildings. Besides, literature states that blockchain technology can be applied to real estate and could be a game-changer in transacting real estate. The focus on a solution for a field problem – the cumbersome transaction process – is in line with design science research (Aken van and Romme, 2009; Hevner and Chatterjee, 2010). Hence, this method is applied in developing a design proposition for a field problem.

In summary, organizations currently work in a decentralized fashion which causes various pain points and challenges. The proposed blockchain database is structured according to the data requirements of a transaction (Property Markets Research Team, 2004), which are split into two elements (indexes): physical (technical) and contractual (commercial-, legal- and financial- documents) elements. Physical and contractual data can be logged on a blockchain based on its consensus mechanism and cryptographic encrypting method, also referred to as cryptographic audit trail or hash chain. The original files are stored on the servers of the involved parties and validation information (class diagram framework) is uploaded in the blockchain. The validated framework consists of all essential data elements of e.g. a contract (e.g. index code, validation date, involved parties etc.). Validated record-keeping is the first step towards creating digital real estate transactions and resolving the pain points in the process.

Although, blockchain technology is what builds digital records of physical and contractual information, it does also come with challenges. These are as a result of the immaturity of the technology, a lack of standardization and limited examples of successful application. Hence the implementation of the proposed model is quite complex. Currently, the correctness of documents need to be validated by validating nodes (oracles) in the network, due to the lack of standardization. For the system to add value, data such as reports and inspection frameworks must be standardized. If this is possible, the record-keeping application could be linked to various aggregation levels (Kadaster, BAG, VHE, etc.) by way of an API. Therefore, data could be automatically validated without the need for oracles, and analyzed by the user. Also, authorization rules in the network could be much more detailed (e.g. data such as contract clauses could be recorded). All this could make the proposed application suitable for managing physical and contractual data, which, consequentially, could enhance the transaction process.

The process is sector wide known to be cumbersome, however there is not a great enough incentive for one single party to develop a blockchain infrastructure – all parties would have to sign up to use it for it to be valuable. Besides, all corporate parties could benefit from more reliability, transparency and efficiency. Hence, a collaboration between banks with a large market coverage would be best placed to take the lead in standardizing documents for financing real estate and, in turn, the development of a blockchain infrastructure as proposed. In this way, involved parties, such as banks, will receive standard information, which they can use to optimize their own workflows (e.g. risk assessments).

The design science research proposes a blockchain based infrastructure to improve the current transaction process of an office building. During validation of the application, all parties indicated that the application is an interesting first step towards a digital and more transparent ecosystem. The structure and quality of data – these are the main elements in a real estate transaction and so are essential if the process is to be streamlined – available will be enhanced by implementing the proposed blockchain infrastructure. The application improves the way specific asset are understood by structuring physical and contractual information in one place, and guarantees the quality of the data by using the blockchain mechanisms. Therefore, the tool is of immeasurable value for the future of real estate data management and the transaction process.

Management summary (Dutch)

Technologische ontwikkelingen zoals blockchain transformeren verschillende sectoren wereldwijd, waaronder de commerciële vastgoedsector. Commerciële vastgoedtransacties staan bekend als tijdrovend en inefficiënt, onder andere vanwege het gebrek aan transparantie van de markt. Dit onderzoek richt zich op de ontwikkeling van een blockchain applicatie die het huidige transactieproces van kantoorgebouwen in Nederland kan verbeteren.

Vanwege de primaire eigenschappen van vastgoed – heterogeen en immobiel – staat de commerciële vastgoedmarkt bekend als inefficiënt op het gebied van data-management. Dit resulteert in relatief hoge transactiekosten in vergelijking tot andere kapitaalmarkten (aandelen, obligaties en fondsen) (Ling and Archer, 2012). Noemenswaardig hierbij is dat banken een belangrijke rol spelen in de huidge vastgoedmarkt. De financiering van vastgoed wordt meestal gerealiseerd door een lening bij een bank (60 % - 70 % LTV) (Gout, 2017, p. 82). Als gevolg van technologische ontwikkelingen, de veranderende vraag naar data en strengere regelgeving (Basel III en Basel IV) staat de traditionele rol van banken als kredietverstrekker onder druk (Deloitte, 2018). In dit verband zouden banken huidige (interne) processen en bedrijfsmodellen moeten analyseren om zich te positioneren in de veranderende markt.

Hoewel recente studies de mogelijkheden van het toepassen van blockchain technologie in de vastgoedmarkt hebben onderzocht, blijven daadwerkelijke applicaties en implementaties uit (Dijkstra, 2017; Seuren, 2018; Veuger, 2017). Alle studies geven echter aan dat blockchain technologie kan leiden tot verbeteringen in efficiëntie, transparantie en daarmee vertrouwen in de vastgoedsector. Daarnaast kunnen banken deze technologie gebruiken om potentiële risico's beter in kaart te brengen en interne processen te stroomlijnen (Dijkstra, 2017; Deloitte, 2017). Dit onderzoek focust zich daarom op de ontwikkeling van een blockchain applicatie om de huidige manier waarop vastgoed wordt verhandeld te verbeteren. Dit kan mogelijk de basis vormen voor nieuwe bedrijfsmodellen en mede tot een toename in stabielere vastgoedinvesteringen leiden.

Het huidige transactieproces van commercieel vastgoed is op te delen in verschillende fases (Crosby and McAllister, 2015; Dijkstra, 2017; Hordijk and Teuben, 2008; Just and Stapenhorst, 2018): preparation, marketing & pre-due diligence, due diligence and completion. Opmerkelijk is dat er momenteel meerdere due diligence fases en onderhandelingen uitgevoerd worden, zowel vanuit de verkopende als de kopende partij, om informatie te verifiëren en te valideren. Een mogelijk risico kan zijn dat binnen het huidige transactieproces partijen de betrouwbaarheid van de aangeleverde informatie betwisten. Bovendien resulteert de gedecentraliseerde manier van werken met niet-gedigitaliseerde documenten in een complex en ongestructureerd proces.

Deze complexiteit is door middel van semi-gestructureerde interviews geïdentificeerd en gekoppeld aan specifieke fasen en taken in het transactieproces. Uit ieder interview komt naar voren dat de knelpunten met name ontstaan in de due diligence fase en completion fase, gerelateerd aan *data structuur* en *data kwaliteit*. Deze knelpunten worden echter gevormd gedurende het beheer van het vastgoed en de voorbereidende fase in het transactieproces. Een logische verklaring aangezien knelpunten zichtbaar worden door het analyseren van data, hetgeen de basis vormt voor de on-

derhandelingen in de completion fase. Het innoveren van het transactieproces en implementeren van nieuwe technologieën, zoals blockchain, kan mogelijk leiden tot een verbetering van dit transactieproces in de toekomst.

Een blockchain gedistribueerd grootboek is eenvoudigweg een nieuwe manier om gegevens te beheren en bestaat uit vijf kernelementen (Hileman and Rauchs, 2017; Seuren, 2018; Swan, 2015; Tapscott and Tapscott, 2016; Tasca et al., 2017): 'cryptography', 'peer-to-peer (P2P) network', 'validity rules', 'consensus mechanism' en 'ledger'. Blockchain en de hieruit afgeleide toepassingen, zoals 'smart contracts', kunnen de betrouwbaarheid, efficiëntie en veiligheid van informatie die wordt overgedragen in een netwerk verbeteren (Swan, 2015, p. ix). Vanuit een theoretisch perspectief kunnen de kernelementen van blockchain technologie een oplossing bieden voor het huidige transactieproces van kantoorgebouwen.

Kortom, op dit moment werken organisaties op een gedecentraliseerde manier waardoor verschillende knelpunten ontstaan in het transactieproces. De voorgestelde blockchain-database is onderverdeeld in twee hoofdelementen (Property Markets Research Team, 2004): fysieke en contractuele elementen. Fysieke en contractuele informatie wordt in een blockchain vastgelegd door middel van het consensus mechanisme en de cryptografische coderingsmethodiek. In de voorgestelde situatie worden originele bestanden opgeslagen op de servers van de betrokken partijen en wordt informatie gerelateerd aan de validatie geüpload in de blockchain. Het hieruit voortvloeiende gevalideerde kader bestaat uit alle essentiële informatie van een element (bijvoorbeeld codering, validatie datum, betrokken partijen). De eerste stap naar het creëren van digitale transacties en het oplossen van de knelpunten in het huidige proces is het valideren van de geregistreerde informatie-elementen.

Hoewel blockchain technologie fysieke en contractuele informatie digitaal registreert, ontstaan er ook uitdagingen. Onder andere het gevolg van de innovatieve technologie en een gebrek aan gestandaardiseerde documentatie. De verwachting is dat de implementatie van het voorgestelde model vrij complex is, bijvoorbeeld omdat de juistheid van documenten momenteel wordt gevalideerd door een aparte instantie in het netwerk, vanwege het gebrek aan standaardisatie. Indien documentatie zoals rapportages en inspecties worden gestandaardiseerd kan het voorgestelde systeem van waarde zijn voor alle partijen. In deze optimale situatie kunnen systemen van verschillende aggregatieniveaus (Kadaster, BAG, etc.) worden gekoppeld. Vervolgens is het mogelijk om data input te controleren door Application Programming Interfaces (API's) in plaats van een specifieke partij in het netwerk. Daarnaast is het mogelijk om autorisatie in het netwerk gedetailleerder plaats te laten vinden op bijvoorbeeld een enkel onderdeel van het huurcontract. Dit alles zou de voorgestelde toepassing geschikt kunnen maken voor het beheren van fysieke en contractuele informatie, die als gevolg daarvan het transactieproces verbetert.

Het proces staat sectorbreed bekend als omslachtig, toch is dat geen beweegreden voor partijen om een blockchain applicatie te ontwikkelen. Indien het gehele netwerk de toegevoegde waarde ziet en deelneemt aan het voorgestelde model, kan dit echter zeer effectief zijn. Alle partijen in het huidige transactieproces kunnen dan profiteren van meer betrouwbaarheid, transparantie en efficiëntie. Voor het standaardiseren van documenten voor de financiering van vastgoed zou een samenwerking tussen banken interessant zijn gezien het marktaandeel van de banken en de mogelijkheid om over betrouwbare informatie te beschikken. Zij kunnen het voortouw nemen in het ontwikkelen van een infrastructuur zoals voorgesteld door de betrouwbare informatie te gebruiken om hun eigen interne processen te optimaliseren. Externe partijen moeten daarvoor standaard informatie aanleveren wat het ontwikkelen van een infrastructuur zoals omschreven mogelijk maakt.

Dit ontwerp gericht onderzoek (Design Science research) stelt een op blockchain gebaseerde applicatie voor om het huidige transactieproces van een kantoorgebouw te verbeteren. Tijdens de validatie van het prototype van de applicatie, hebben alle partijen aangegeven dat de applicatie een interessante eerste stap is naar een digitaal en meer transparant ecosysteem. De structuur en kwaliteit van de informatie die beschikbaar is zal worden verbeterd waardoor interne processen

geoptimaliseerd kunnen worden. De voorgestelde applicatie verbetert de manier waarop een kantoorgebouw wordt verhandeld door fysieke en contractuele informatie op één plaats te structureren en garandeert daarnaast de kwaliteit van de gegevens door gebruik te maken van de blockchain toepassingen. Dat maakt de tool van onschatbare waarde voor de toekomst van het beheer van vastgoed gerelateerde informatie en het optimaliseren van het transactieproces.

Abstract

Technology advances, such as blockchain, are transforming markets across the globe, including the commercial real estate sector. Due to the commercial real estate markets' fundamental characteristics – heterogeneity and immobility – real estate transactions face the joint challenges of time consuming process, information inefficiencies and corresponding high transaction costs. Although recent studies have theoretically examined the possibilities of applying blockchain technology, applications remain unclear. The characteristics of blockchain technology could lead to improvements in efficiency, transparency and therefore trust. Therefore, this research focuses on a blockchain solution for a field problem – the cumbersome transaction process – which is in line with design science research. Hence, this method is applied in developing a design proposition.

In summary, organizations currently work in a decentralized fashion which causes various pain points and challenges. To support this, semi-structured interviews were conducted to identify and map pain points to specific phases and tasks in the transaction process. For mapping pain points the transaction process is visualized by means of Business Process Model and Notation. The obtained data is analyzed according to the Grounded Theory. From empirical findings it could be stated that major pain points are related to *data structure* and *data quality*. To resolve these pain points a blockchain application is proposed and pragmatically validated. Object related information, such as contracts, can be logged on a blockchain based on its consensus mechanism and cryptographic encrypting method. Original files are stored on the servers of the involved parties and a validated framework – consisting of essential information, such as coding, validation date, involved parties – is uploaded in the blockchain and visualized by means of UML and a clickable user interface. Validated record-keeping is the first step towards creating digital real estate transactions and resolving the pain points in the process.

Hence, this design science research proposes an infrastructure for a blockchain-based application to improve the current way real estate is transacted by introducing a more comprehensive, better quality and more complete asset information overview, which streamlines the transaction process, may payoff for all involved parties and could potentially increase the size of managed global real estate.

Abbreviations

API	**A**pplication **P**rogramming **I**nterface
BPMN	**B**usiness **P**rocess **M**odel and **N**otation
CFL	**C**ommercial- **F**inancial- and **L**egal index
CRE	**C**ommercial **R**estate **E**state
DL	**D**istrubuted **L**edger
DLT	**D**istrubuted **L**edger **T**echnology
GT	**G**rounded **T**heory
IM	**I**nvestment **M**emorandem
HoT	**H**ead **o**f **T**erms
LTV	**L**oan **t**o **V**alue
NDA	**N**on- **D**isclosure **A**greement
P2P	**P**eer-**t**o-**P**eer
PoA	**P**roof-**o**f-**A**utority
PoS	**P**roof-**o**f-**S**take
PoW	**P**roof-**o**f-**W**ork
PM	**P**ropert **M**anagement
RED	**R**eal **E**state **D**evelopment
REIT	**R**eal **E**state **I**nvestment **T**rust
SPA	**S**ales and **P**urchase **A**greement
TTP	**T**rusted **T**ird **P**arties
UML	**U**nified **M**odeling **L**anguage

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Chapter 1

Introduction

The first chapter introduces the topic of this research, starting with an introduction of commercial real estate, transaction process and certain trends. Subsequently, Section 1.2 covers the problem statement and objective, which result in a main research question (Section 1.3). Finally, in Section 1.4 and 1.5 the practical- and scientific relevance are discussed.

1.1 Background

> *'Artificial Intelligence (AI). Big data. Blockchain. Quantum computing. Robotics. Technologies are transforming markets across the globe.'*

Technology advances are transforming markets across the globe, including the real estate sector. Parties acting in the commercial real estate (CRE) sector are evaluating their processes and institutions like banks, acting as trusted third party (TTP), are evaluating how to position in the future (Deloitte, 2017, 2018). The potential of those new technologies is not only to streamline existing markets, but also to redistribute markets and create new ones. Technology advances could increase efficiency, transparency and security in sectors across the globe (Schneider et al., 2016).

On the one hand, real estate is a unique, complex and the largest asset class in the world, US$228 trillion in 2016 (Savills, 2017). History shows that real estate plays an important role in economies worldwide, is known to resist change, and seemingly allergic in adopting new technology (Spielman, 2017). The importance of real estate lies in the fact that it has been one of the three major asset classes that insurance companies and pension funds like to invest in – either directly, through property funds or Real Estate Investment Trusts (REITs) (Baum, 2017). Currently, real estate have become the largest asset class of the global stock market next to equities and bonds (Baum, 2009). However, real estate assets are distinctly different compared to equities and bonds by having high transaction costs, long-term commitment, regulations and other barriers to entry. In addition Ling and Archer (2012) stated that CRE assets are characterized by two primary characteristic: heterogeneity and immobility. These primary characteristics result in a market that tends to be localized and highly segmented, involving many hidden costs, regulations, a lack of transparency in information and high transaction costs due to involvement of TTPs (Ling and Archer, 2012, p. 13). It can be assumed that these characteristics have implications for the overall efficiency of the real estate market, which payoff in a size of managed global real estate investment market of US$7.3 trillion in 2017 (JLL Global Research, 2018, p.3). This inefficiency – the size of the global real estate asset class compared to the size of managed global real estate investment – implies that streamlining the real estate transaction process by lowering barriers and more or better asset and market knowledge may payoff.

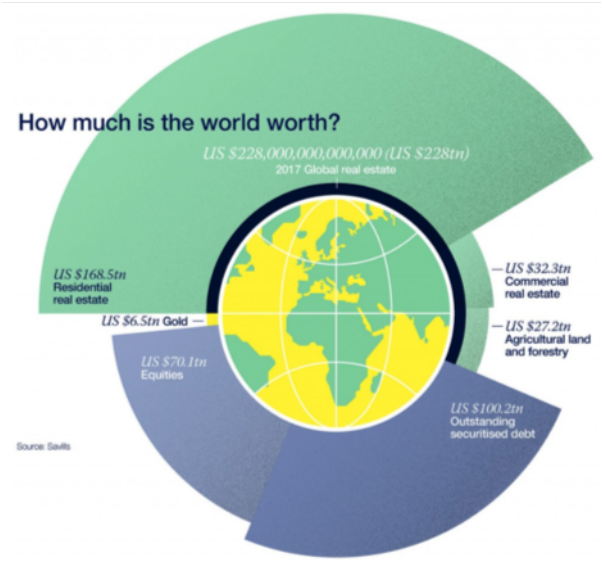

Figure 1: How much is the world worth? Source: (Savills, 2017).

On the other hand, from a banks perspective, financing commercial real estate is usually done through lending from banks, where 60 – 70 percent of their financing comes from. Due to technology advancements, changing client demand and stricter regulation (Basel III & Basel IV) the traditional role of institutions, like banks, are under pressure. Since Basel III, and soon Basel IV, sets higher requirements on banks and borrowers, alternative ways of financing could be more favourable (Schneider et al., 2017). According to Marchand (2016) crowdfunding real estate might be the next major innovative investment structure (Marchand, 2016). Another example is presented by Gout (2017). Gout (2017) proposed a new business model in the residential mortgage domain. The model is a blockchain technology based digital mortgage marketplace which adds value for all involved stakeholders. The study of Gout (2017) showed that alternative funding by use of blockchain technology can be an opportunity in the transaction process (Gout, 2017). Crowdfunding and a digital mortgage marketplace are examples of 'enablers' of new business models, by changing for example the value proposition, or changing one or more of the 'building blocks' of the Business Model Canvas by Osterwalder and Pigneur (2010).

It can be assumed that – for banks to stay relevant – new technologies must be researched. An efficiency improvement in real estate transactions, such as better property knowledge, could lead to both reductions in (transaction) costs, time and a higher demand for real estate investments. Recent studies of Dijkstra (2017), Seuren (2018) and Veuger (2017) focus on the applicability of blockchain technology in the real estate sector. Although all studies describe blockchain technology as a technology that can improve the real estate sector, blockchain applications remain. The studies are explorative of nature and conclude that there are different opportunities for the implementation of blockchain in the real estate sector.

Due to the characteristics of real estate, the market for buying, selling, and leasing real estate tends to be inefficient (Ling and Archer, 2012, p. 13). Furthermore, banks are facing changes caused by technology advancements, changing client demand and stricter regulations (Gout, 2017). In this context, for banks to stay relevant business model 'enablers' should be researched. According to literature blockchain technology could lead to an enhancement of efficiency in data management, a technology for banks to better understand risks associated with real estate. Furthermore, transactions in real estate becomes easier, which could result into 'enablers' for new business models and higher demands for real estate investments from a broader audience.

1.2 Problem definition

The first chapter introduces the topic by starting off with the background, certain trends, and developments in the CRE sector. Based on this insight a problem is defined which forms the basis for this study and the research questions, which is followed by the scientific and practical relevance.

Real estate is characterized by its heterogeneity and immobility, which result in high costs (due to the number of stakeholders) and a lack of transparency – the need of validating large volumes of documentations with information of a transaction – a process famous for being costly and time consuming. These primary characteristics make real estate a complex and inefficient asset class. Additionally, financing commercial real estate is usually done through lending from banks, 60% – 70% LTV. Due to technology advancements, changing client demand and stricter regulation (Basel III & Basel IV) the traditional role of banks is under pressure. Since Basel III, and soon Basel IV, sets higher requirements on banks and borrowers, alternative ways of financing could be more favourable

Based on technology advancements, characteristics of real estate and changing regulations, new business model 'enablers' should be analyzed. It can be assumed that an efficiency improvement in the transaction process of real estate could lead to both enormous reductions in transaction costs, and time and therefore an increase of liquidity. In order to make this process more efficient, one could think of implementing a technological innovation that causes digitization, transparency, record keeping and transferring digital assets.

Blockchain technology might benefit the sector by solving above mentioned issues with its capability of transferring building related information via the digital world. Information about a building, such as title registration with recent owners, sales prices, lease contracts, loans, maintenance contracts, and even building materials and their condition can be recorded digitally on a blockchain. The information can be linked to a token. The seller is able to sell his token, which represents the property (and all the data). This may result in an optimized transaction process, alternative way for financing real estate and provide a solution for the lack of well-structured data of a building. Moreover, higher demands for real estate investments from a broader audience could be expected, especially when transactions in real estate becomes much easier and cheaper.

One could imagine, that due to the characteristics and inefficiencies in real estate transactions, blockchain technology might improve this process. However, due to the immaturity of blockchain technology in the real estate sector, developed models and platforms are still in Proof-of-Concept stages and have not formally launched. This research aims to propose a blockchain technology solution for the CRE transactions:

> *This research will analyze the enhancement of blockchain technology in the transaction process of an office building. By gaining knowledge about the current transaction process of an office building and blockchain technology.*

1.3 Research question

Following from the problem statement the main research question that arise and to be answered in this research is defined as:

> **'How to implement blockchain technology to improve a real estate transaction of an office building?'**

To answer the main research question, the following research questions are established[1].

1. **What does a commercial real estate transaction and specific the transaction process of office buildings look like?**
   In order to explore the current way of working, characteristics (stakeholders, data streams, etc.) of a commercial real estate transaction related work will be studied. Based on this literature study the current transaction process of an office building could be visualized by means of a flowchart.
2. **What is the status quo in regard to blockchain technology in real estate?**
   To explore the potential of blockchain technology in the current transaction process of an office building, a clear understanding of the general functioning and possibilities of blockchain will be analyzed. In addition, to create an overview of the status quo of blockchain, examples of blockchain technology implementations in the real estate sector will be outlined.
3. **What pain points occur during the transaction process of an office building?**
   Once the current transaction process (theoretical framework) is visualized by means of a flowchart, involved parties will be asked to identify the pain points in the defined transaction process. Based on the identified pain points it could be analyzed how blockchain technology enhances the transaction process.
4. **What blockchain technology features could be used to improve the current transaction process of an office building?**
   Once research and validation regarding the transaction process of an office building is finished, an infrastructure (architecture) for a model without blockchain technology will be proposed. Based on this model it could be analyzed what blockchain features could enhance the proposed solution.
5. **What does an office transaction based on the proposed blockchain model look like?**
   The model will be visualized and validated to analyze its value. With a back- and front-end prototype the proposed blockchain model will be demonstrated to users. Multiple parties are interviewed to validate the model in the transaction process of an office building.
6. **What could be the potential role of a bank in a blockchain based transaction?**
   This study is conducted in collaboration with a dutch bank. Therefore, the potential role of a bank in a blockchain based transaction will be analyzed.

[1] Methodologies used for answering the research questions will be explained in Chapter 4 on page 31.

1.4 Scientific relevance

Technology advances – such as blockchain technology – are transforming sectors across the globe, as well as the real estate sector. Levin (2018) noted that last year various studies propose models and platforms based on blockchain technology. But due to the immaturity of blockchain technology in all sectors, developed models and platform are still in Proof-of-Concept stages and have not formally launched. Although, Levin (2018) mentioned multiple proof-of-concept blockchain model related studies, recent researches related to (transacting) commercial real estate and blockchain technology of Dijkstra (2017), Seuren (2018) and Veuger (2017) explore only the applicability of blockchain technology by means of an explorative research. Research related to blockchain technology applications in the transaction process remain unclear. With the enormous interest in this technology, including smart contracts and tokenization of buildings, and the lack of scientific research shows a need for understanding the possibilities of blockchain technology applications in the real estate transactions. This research focuses on the above described scientific knowledge gap.

1.5 Practical relevance

As aforementioned, due to technology advancements, and changing client demand as well as stricter regulation (Basel III & IV) the traditional role of institutions, like banks, are under pressure. Since Basel III, and soon Basel IV, sets higher requirements on banks and borrowers, alternative ways of financing could be more favourable. It is within this context of challenges and opportunities that alternative financing tools should be sought.

In recent studies blockchain technology solutions are mentioned as a remedy that make the real estate transactions more efficient. Blockchain technology solutions causes transparency, create more liquidity and could lowering barriers for parties to gather their investment. Increasing transparency in the real estate market will allow banks to get a better understanding of the risks associated with real estate. If more information about the risks of real estate is known, the risk aversion against real estate as an investment class may change. However, studies related to blockchain applications in transacting real estate remain unclear.

It can be assumed – based on studies related to the applicability of blockchain technology – that an efficiency improvement in real estate transactions could lead to enormous reductions in time, transaction costs and may provide a solution for the lack of well-structured data of a building. However, the question that raise is: "How should the application look like that enhance the transaction process?".

1.6 Reading guide

This master thesis is structured in such a way that any reader can follow the line of reasoning. Therefore, the first two chapters extensively discuss the context of the research. Both chapters (Chapter 2 and 3) form the theoretical framework. These chapters describe the CRE transaction process and sketch out the fundamentals and current development of blockchain technology. Subsequently, Chapter 4 defines the research methodology of this research based on the conclusion of the theoretical framework. Based on the proposed research design and described tools further research is performed. Chapter 5 discuss the empirical findings. The aim of this chapter is to gain more knowledge regarding pain points in the transaction process. Subsequently, Chapter 6 propose a solution that enhances the current way of transacting real estate. The proposed model is visualized based on a prototype and thereafter validated in Chapter 7. In the final chapter, answers to the research questions are presented, discussed and recommendations for further research drafted.

Chapter 2

Commercial real estate transaction process

The transaction process of commercial real estate assets differs fundamentally from purchasing assets from a stock market. Its fundamental characteristics leads to a relatively complex transaction process which result in e.g. a time-consuming process involved with high transaction costs. Therefore, real estate is known as an illiquid asset class (Baum and Hartzell, 2012, p. 29). But, '*What is the transaction process of commercial real estate?*'.

This chapter aims at providing an answer to the first research question, which is formulated as follows: '*What does a commercial real estate transaction and, more specific, the transaction process of office buildings look like?*'. To do so, this chapter extensively discusses related work regarding commercial real estate characteristics and -transaction market (Section 2.1), followed by an elaboration of the transaction process of a commercial real estate asset, particularly a transaction of an office building (Section 2.2). Finally, this chapter is wrapped up in (Section 2.3) with an answer to the first research question.

2.1 What is commercial real estate?

Before considering the elements in a commercial real estate transaction (CRE) process a short description of what is meant by CRE, its general characteristics and where transactions take place within the real estate domain is given. Hence, before considering the CRE transaction process, it is necessary to define '*What is CRE?*'.

2.1.1 Definition

History show that real estate plays an important role in economies worldwide – with a total market value of $217 trillion. The industry for transacting CRE is concerned with buying, selling or leasing real estate objects. But, '*What is real estate?*'. Lin and Vandell (2007) stated: 'when people think of real estate, they often think of their homes in their community, the business of buying and selling houses or offices, but real estate is more than selling houses or offices'. Real estate in its most common use is identifiable as tangible assets of land and buildings. In addition, real estate refers to the 'bundle' of rights associated with ownership as well (Baum, 2009; Ling and Archer, 2012).

Tangible assets can be assigned to different categories: commercial, industrial & logistics and residential real estate. Dierick et al. (2017) describes CRE as any income-producing real estate (e.g. office-, restaurant-, hotel-, shop property, leasing and renting of residential). CRE is 'owned'

by non-occupiers, in contrast to residential property, where rights of ownership and occupation are usually with its occupiers. Another asset class within CRE is industrial and logistics real estate. This research focus on tangible assets within the domain of CRE in the Netherlands, more specific for this research, offices.

2.1.2 Characteristics of commercial real estate

CRE assets in the Netherlands are part of the larger capital market, in which assets of all types are traded. However, the characteristics of real estate assets and related markets are distinctly different compared to other assets traded in this market (e.g. bonds, stocks, etc.). The real estate market is often characterized by two fundamental (physical) characteristics namely a heterogeneous and immobile product; hence not one building is the same and the location cannot be changed. Although these characteristics are physical in nature, they impact the associated markets for buying, selling, and leasing real estate (Ling and Archer, 2012, p. 2). Consequentially, Ling and Archer (2012) defines the real estate market as localized and segmented, which results in a market with relatively high transaction costs – as non-physical characteristics. These four characteristics result in a market that tends to be illiquid. This corresponds to the conception of Vazquez (2015), who argues: '*real estate is considered illiquid because it can not be easily sold without a substantial loss in value*'. Thus, the illiquidity of real estate refers to the ease to transact property. In addition, Geltner et al. (2001) indicate that the real estate market with a relatively low degree of liquidity – it takes longer for sellers to find buyers – results in a market with typically higher transaction costs (the costs of buying and selling assets) and tends not to be as informationally efficient as other markets. These implications occur due to the uniqueness of real estate assets and parties involved in the transaction process. Transacting in real estate is based on an agreement between two unique parties and the same asset – a specific office building – is not sold frequently, which results in an asset value that does not incorporate or reflect news and information (Geltner et al., 2001; Vazquez, 2015). The interconnection between the fundamental characteristics, market and implications are schematically illustrated in Figure 2.

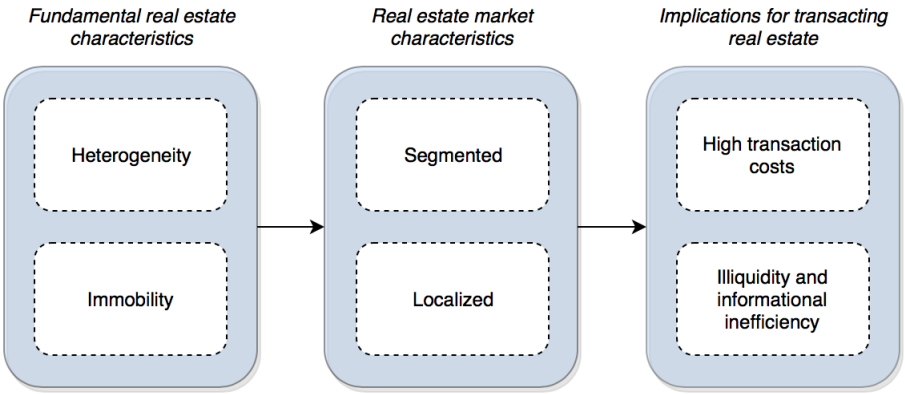

Figure 2: Real estate characteristics. Source: (Seuren, 2018).

In addition, CRE is divided into the space market and the asset market. Both, DiPasquale and Wheaton (1992) and Geltner et al. (2001) distinguished those two inter-related markets within the CRE market in more detail. DiPasquale and Wheaton (1992) stated that these markets are most clear when buildings are not occupied by their owners.

The real estate *space market* is the market for the usage of real property, also referred to as the rental market (Geltner et al., 2001, p. 3). For example a student exchange rent with the owner of the property for *the right to use* the property (land and build space). Geltner et al. (2001) outlines the demand- and supply side within this market. On the one hand, the demand side of this type

of market includes individuals, household, or firms who want to use space for consumption or production purposes (Geltner et al., 2001, p. 3). As an illustration the 'residential' space market is used for housing and the 'offices' space market is used for commercial purposes and to conduct businesses. On the other hand, the supply side includes real estate owners who 'rent' space to tenants. 'Rent refers to the price of the right to use space for a period of time' (Geltner et al., 2001, p. 3). For example, $140 per square meter per year – in case of an office space. The real estate space market is highly segmented due to the immobility (primary characteristics) of real estate. Hence, the market rent for office space may differ significantly between Amsterdam and Groningen.

Besides the space market, both DiPasquale and Wheaton (1992) and Geltner et al. (2001) discuss the asset market, which refers to the market for the ownership of real estate assets (Geltner et al., 2001, p. 11). In this market buyers exchange money for ownership rights or -title, also referred to as property market. As stated before, this market is a part of the larger capital market, consisting of bonds, stocks, etc. Cash flows (future rents and risk) and yield requirements play a decisive role in the real estate asset market, as these assets compete in the capital market with other assets (e.g. bonds, stocks, etc.). The discussed markets are connected by the real estate development (RED) industry. Together, the RED industry, asset market, and space market form the real estate ecosystem. In contrast to other assets in the capital market, buildings are long lived assets. The demand in the real estate market is result of economic changes and supported by the RED industry. It can be assumed that the RED industry is the converter of financial capital into physical capital. Hence a symbolic feedback loop between the markets occur (DiPasquale and Wheaton, 1992; Geltner et al., 2001).

2.1.3 Transaction market

With the definition and characteristics of CRE a global overview has been drafted. It can be concluded that transactions in CRE are known for its high transaction costs, information inefficiency and take place in the real estate asset market. The next section distinguish transaction in the real estate transaction market in more detail.

Transactions in real estate take place in the asset market which is part of the capital market. According to Baum (2017) 'as with all equity-type assets, the performance of real estate (e.g. change in demand) is linked to some extent to the performance of the economy, and like all assets its performance is linked to the capital markets. The economy is the basic driver of occupier demand, and, in the long term, investment returns are produced by occupiers who pay rent.' (Baum, 2017, p. 14). The total investment volume in CRE as asset class has been growing over the past years. This has resulted in a scenario that CRE assets are seen as an 'alternative asset' class that floated on the periphery of traditional investments (e.g. shares and bonds). CRE is the third largest asset class in the capital market. However, the real estate asset market is characterized by numerous challenges. The illiquidity of real estate as asset class, high (transaction) costs due to operational ineffectiveness and lack of access to investment opportunities. Some of the other characteristics that make real estate unique compared to other investment alternatives, such as shares are defined by Seuren (2018). Seuren (2018) defines in addition to the previous described fundamental characteristics, heterogeneity and immobility, two factors in which real estate differs from other assets: financing and risk-return rate. Financing can be subdivided into four general categories: Public equity markets (REITs[2]), Private equity markets (Real Property), Public debt markets (MBS[3]), Private debt markets (Whole Mortgages). As can be seen in Table 1, real estate assets fit in all four financing categories (Geltner et al., 2001).

[2]Real Estate Investment Trusts (REITs): 'offer publicly traded common stock shares in companies that essentially do nothing but own (and manage, and buy and sell) income-producing properties and mortgages.'(Geltner et al., 2001, p. 13)

[3]Mortgage-Backed Securities (MBS): 'publicly traded bond like products that are based on underlying pools of mortgages, which are real-estate-based debt products.'(Geltner et al., 2001, p. 13)

Table 1: Major types of capital asset markets and investment products. Source: (Geltner et al., 2001, p. 11).

	Public Markets	**Private markets**
Equity Assets	Stocks *REITs* Mutual funds	Real Property *Private equity* Hedge funds
Debt Assets	Bonds *MBS* Money instruments	Bank loans *Whole mortgages* Venture debt & LBOs

According to Geltner et al. (2001) public trade assets are generally traded more frequently than private assets. As a result public markets are more liquid than private markets. Transactions within the private market generally involving whole assets rather than shares of assets (public market). Debt and equity are two different types of capital assets, both can be traded in either public or private types of assets. Geltner et al. (2001) defined debt assets as assets that give their owners the right to future cash flows paid out by borrowers on loans (e.g. interest payments). By way of contrast, equity assets give their owners the rights to the residual cash flows generated by an underlying asset (Geltner et al., 2001, p. 12).

The expected risk-return rate of a property is distinguished by Seuren (2018) as fourth characteristic – in which real estate differs from other assets. Seuren (2018) stated that "the risk-return rate is largely determined by the asset class and the location of the property, but the structure of the tenancy, vacancy and the quality of the design also play an important role" (Seuren, 2018, p. 45). The risk-return rate within CRE could be classified according to the following types: Core, Core+, Value added and Opportunistic (Worzala and Sirmans, 2003). The core segment is known as high-end real estate, with a relatively low expected risk and low return. In contrast to the core segment, the opportunistic segment is known for its relatively high risks and high return. It could be noticed that within the core segment all information is available during the transaction period. However, within other segments less information is available in the same period, which result in more uncertainty (risk). The associated risks in the different segments of real estate investments result in return differences (Baum, 2009; Formigle, 2016; Worzala and Sirmans, 2003).

With the above-mentioned characteristics and definitions, a comprehensive overview of CRE and different transaction definitions has been drafted. It can be summarized that the fundamentals of CRE as asset – heterogeneity and immobility – result in information inefficiency and a market with relatively high transaction costs in comparison to other asset classes. Transactions in CRE take place in the real estate asset market, which is part of the capital market (consisting of bonds, stocks etc.). This market can be divided in four categories: Public equity markets, Private equity markets, Public debt markets, Private debt markets. This research focuses on (existing) office transactions in the private equity market. The next chapter will discuss the transaction process of an office building within the private equity market.

2.2 Transaction process of an office building

CRE (private equality) transactions take place in the real estate asset market. This section aims at providing an answer to the second part of the first research question, which is formulated as follows:'*... and, more specific, the transaction process of office buildings look like?*'. There are multiple studies considering the real estate transaction process (Bartke and Schwarze, 2015; Crosby and McAllister, 2015; Devaney and Scofield, 2015; Dijkstra, 2017; Hordijk and Teuben, 2008; IPF Working Group, 2012; Property Markets Research Team, 2004; Seuren, 2018). In this section the transaction process of an office building will be drafted.

2.2.1 Actor roles

There are various actors involved in a CRE transaction. As a result, high costs and information inefficiency within real estate transactions occur, by means and perspectives. Each actor has its own expertise and value to add to the chain. Although the amount of involved actors depends on the complexity of the transaction, there are actors that are always involved: initiator (seller) and completer (buyer). More specific for this research, the seller and buyer of an office building are referred to as investors. Besides the seller and buyer, other roles could be distinguished during a transaction such as appraisers, brokers, funders (mostly banks) and legal advisors (Figure 3), according to Dijkstra (2017) and Seuren (2018). The actors will be described in more detail below.

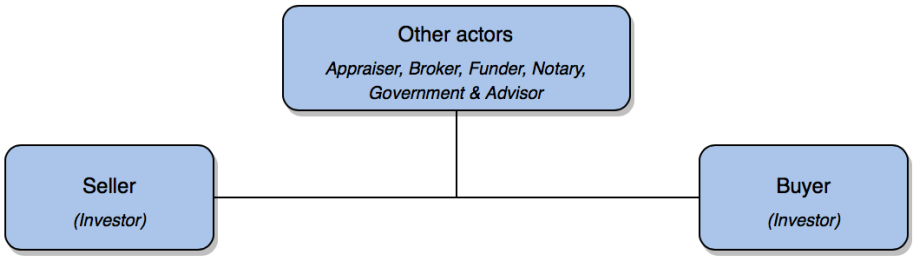

Figure 3: Schematic visualization of actors in a transaction process

The *investors* (seller & buyer) are, most of the time, the initiator of the transaction process, which can either be a public (institutional) or private organization. The aim of the investor is financial return as result of invested capital – income flow from tenant or a potential increase of the economic value of an asset.

When transacting CRE the value of the property has to be determined. Currently, the *appraiser* is responsible for the valuation of the real estate properties based on location aspects, construction quality etc. On one hand, the value of real estate could be determined by a specific valuation organization. On the other hand, brokers can offer a wide range of services including valuation.

Brokers are advisors that in their core bring demand and supply together (Crowston and Wigand, 1999). The broker can assume two distinct roles: (1) sales broker and (2) buyers broker. The role of the broker depends on the role of the client: (1) selling or (2) buying. Brokers are involved in the acquisition and disposition of a property by supporting the buyer and seller of a property. During the operational phase brokers are responsible for successfully acquiring new tenants and renegotiating contracts with existing tenants in the building. Over the years the profile of brokers evaluated towards a full-service organization and are now functioning as an one stop shop real estate advisor. Larger broker firms can offer a wide range of services such as, property & asset management, research & consultancy, valuations, etc. (Crowston and Wigand, 1999).

In order to obtain enough funds for acquiring properties, investors can involve a *funder* into the process. A funder, such as a bank, is able to finance a part of the transaction price via a loan, called loan to value (LTV) ratio. For example, banks are funders that can fund 60% - 70% of LTV according to Basel III. The investor needs to pay an interest rate for making use of the loan. If the investor is not able to meet its financial obligations towards the bank, the underlying real estate asset is functioning as a security.

The *legal advisors* is mostly seen as signing agent. For example, the SPA is only valid if the documents are executed by notary deed (Just and Stapenhorst, 2018, p. 47). Only a notary is authorized to executed by notary deed and validate the sales agreement. Furthermore, the task of a legal advisor is to verify the title of ownership. In the Netherlands there is a sufficient system which is called 'Kadaster'.

2.2.2 Transaction phases

The real estate transaction process is seemingly different from that in financial markets, as mentioned before. Partly, due to the uncertainty in time for linking a seller to a buyer and the establishment of transaction prices in the real estate market. This corresponds with the fundamental characteristics of real estate (Devaney and Scofield, 2015; Geltner et al., 2001; Ling and Archer, 2012). Lin and Vandell (2007) explains this distinction from a classical financial market and price establishment point of view. In contrast to real estate assets, products in the financial market (e.g. shares) are known for its homogeneous and ability to be traded frequently. If zooming on the transaction of real estate asset, Lin and Vandell (2007) stated that the real estate market – based on its primary characteristics – is known for its 'unrestricted availability of buyers and sellers at the market price, and prices are determined by market clearing' (Lin and Vandell, 2007, p. 297). This results in an asset group which is not frequently be traded – compared to products in the financial market. Additionally, in the financial markets sellers are able to sell their products at any time. In contrast, products in the real estate can not be sold at any time. Before a transaction can take place a potential buyer should show his interest by offering at least a higher price than the seller's reservation price. Hence, due to this uncertainty parties in the real estate market face financial risks and market risks. This makes real estate transactions complex, compared to transactions in the financial market (Lin and Vandell, 2007, p. 297).

Although, the transaction process of a real estate asset is comparable with transactions of other assets, due to its characteristics (Section 2.1.2) there are some differences. Literature differentiates various phases within real estate transactions (Crosby and McAllister, 2015; Dijkstra, 2017; Hordijk and Teuben, 2008; Property Markets Research Team, 2004; IPF Working Group, 2012; Just and Stapenhorst, 2018; Seuren, 2018). McNamara (1998) explored transacting CRE on behalf of institutional investors. McNamara (1998) divided the CRE transaction process – heads of terms/price agreements, exchange and completion - into three phases, (1) either search or marketing, (2) due diligence and (3) settlement (Property Markets Research Team, 2004). Corresponding to the phases determined by Property Markets Research Team (2004). Crosby and McAllister (2015) add a pre-marketing phase. Hordijk and Teuben (2008) describes the pre-marketing phases as 'the period between the decision to sell a particular asset and the assembly of all necessary information on the asset for the sale by the investor' (Hordijk and Teuben, 2008, p. 40). The pre-marketing period makes the transaction process of real estate different, compared to the financial market. In financial markets information is available at any time. In contrast to the financial market, a potential buyer in the real estate market gains knowledge by asking information from the seller. Based on the phases described by Property Markets Research Team (2004); Crosby and McAllister (2015), Hordijk and Teuben (2008) divides the CRE transaction process into six phases: (1) real estate portfolio decision to sell particular sector or sub-sector, (2) decision to sell a particular asset, (3) pre-marketing period, (4) marketing period, (5) due diligence period and (6) exchange to completion (Hordijk and Teuben, 2008, p. 41). Just and Stapenhorst (2018); Seuren (2018) both analyze due diligence (DD) in the context of real estate transactions. Hence, both divided the transaction process into four phases (seven sub phases): (1) sales process, (2) Pre-due diligence & market analysis, (3) Due diligence & negotiation, (4) Sales and Purchase Agreement (SPA) phase. Dijkstra (2017) on his turn summarized this into four main phases, from a sellers point of view (Figure 4). During each phase, data is transferred between involved stakeholders. The required data is elaborated in Section 2.2.3 according to IPF Working Group (2012).

Figure 4: Simplified visualized real estate transaction process

The *preparation phase* consists of elements prior to the actual transaction process. The investor makes the decision to sell or buy a real estate asset or portfolio. In some literature this phase is called the pre-marketing phase or sales process. During the preparation phase all information (data) of particular assets will be collected in a data room and forms the input for the real estate transaction process. The seller could (optionally) select a (sellers) broker for the upcoming stages. The asset related information and documents (e.g. general market overview & asset aspects, technical quality (CAPEX[4]), assessments of current & expected rent, etc.), are summarized in an investment memorandum (IM). The function of an IM is to direct the attention of potential investors and obtain an overview of the asset(s). Additionally, detailed information regarding the transaction process is described in a process letter. Before sending asset specific information to potential buyers they need to sign a non-disclosure agreement (NDA). After signing the NDA, the process letter with the following documents attached will be send to the potential buyer (Just and Stapenhorst, 2018).

1. Investment memorandum including asset specific information.
2. A rent roll (e.g. MS Excel format).
3. A list of expected CAPEX (e.g. MS Excel format).

From a buyers point of view the preparation phase consists of market exploration and subsequently creating a shortlist of potential assets based on investment strategy parameters.

Once the preliminary information is drafted, the *marketing phase* will start from a sellers point of view and *pre-due diligence phase* from a buyers point of view. Since, the seller needs to find potential buyers and the buyer needs to select a potential asset that fit within the formulated strategy. Both marketing as pre-due diligence are part of the *marketing* phase (Dijkstra, 2017). Once the buyer select a specific asset the buyer will show his interest, sign the NDA and receive preliminary information (process letter, IM, rent rolls and expected CAPEX). The preliminary information is supplemented with (public) market information. Based on the obtained information – such as lease contracts, financial agreements and technical inspections – checks will be assessed, validated and calculated (Seuren, 2018, p. 53). The assessed, validated and calculated information give the buyer more understanding about the asset and corresponding value. During this phase several experts experienced in all fields (e.g. appraisers, brokers, etc.) could be involved to make assumptions. If the potential buyers decides that the preliminary information is positive, an initial bid and subsequently non-binding head of terms is drafted. An initial bid consist of the offered purchase price and the underlying assumptions and reservations (board approvals, due diligence exercise, etc.). Often, the head of terms is drafted without consulting lawyers (Just and Stapenhorst, 2018, p. 30-31).

During the marketing phase the received bids of potential buyers are assessed. Once the seller select a buyer the head of terms will be signed by both parties. After signing the head of terms the (buyers) '*due-diligence*' will start.

The term '*due diligence*' (DD) describes a process (Just and Stapenhorst, 2018, p. 6). Buyers DD is the process of checking all the relevant available information before the purchase is actually made. The due diligence phase starts with opening the data room for all involved parties by the seller or sellers broker. Subsequently the data is checked for completeness and accuracy by the buyer, and external parties are instructed that the data room is open. After checking the data for completeness and accuracy external advisors usually physically inspect the (office) building and draft their red flag assessments. The red flag assessments of external advisors are part of the general red flag report drafted by the buyer or buyers broker. A red flag report include an identification of any substantial risk in regard to the specific asset. The red flag documents form the input for the (re)negotiation of the final bid, the completion phase starts.

The final phase of a commercial transaction is the *completion* phase (final bid & closing the

[4]Capital expenditure (CAPEX) is a preview of pending maintenance and repair

deal). After the red flag negotiation a mark-up version of the SPA is drafted including additional guarantees. The negotiation of the red flag report can result in refrain of the buyer from the deal, because the risk increases due to red flags. An other result could be that specific red flags will be priced in the head of terms. The red flags and head of terms are used as input for the sale and purchase agreement (SPA). Mostly based on the red flags the initial purchasing price formalized in the head of terms is adjusted. The SPA draft is negotiated and a final bid formed in the mark-up version of the SPA (Just and Stapenhorst, 2018, pp. 45-46). The final SPA version is negotiated with the seller and only valid if the conditions and all ancillary agreements (offers and options) have been notarized and executed by notarial deed (Just and Stapenhorst, 2018, p. 47). The transaction process of an office building is formally closed after signing the SPA by both parties and change of title in the 'kadaster'.

2.2.3 Information flow

The general transaction process of an office building is defined in Section 2.2.2. During this process different documents of information are hand over between the seller and buyer (e.g. IM, NDA, HoT, SPA etc.). IPF Working Group (2012) came up with a more in-dept information checklist to streamline the transaction process. The data elements in this checklist can be elaborated into nine elements: marketing, legal title & searches, management information, design & construction, utilities, planning/statutory/ infrastructure, physical conditions, rate/outgoing and financial (IPF Working Group, 2012, pp. 12-13). Dijkstra (2017) uses this information checklist to identify the information flow of the transaction process (Appendix A). However, Dijkstra (2017) adjusted some content of the underlying nine elements to be applicable for Dutch properties. Streamlining the transaction process reduces the transaction time and costs, and benefits in the form of better information and associated risks management (IPF Working Group, 2012). Currently, during the preparation phase the seller gather all property related information. This information checklist forms a basis of the documents transferred between parties during the transaction process.

2.3 Summary

Based on a literature study regarding the transaction process of commercial real estate, the first research question can be answered: '*What does a commercial real estate transaction and specific the transaction process of office buildings look like?*'.

Commercial real estate (CRE) – offices, industrial and logistics and residential real estate – is defined as tangible income producing assets of land and buildings, but refers to title of ownership ('bundle' of 'rights') as well (Baum, 2009; Dierick et al., 2017; Ling and Archer, 2012). In this research CRE is scoped to existing office buildings in the Netherlands. Due to the markets' fundamental characteristics – heterogeneity and immobility – real estate transactions face the joint challenges of information inefficiencies and corresponding high transaction costs (Ling and Archer, 2012). Transactions in CRE take place in the asset market, which is part of the larger capital market. This market is divided into four categories (Geltner et al., 2001; Seuren, 2018): Public equity market, Private equity markets, Public debt market and Private debt market. This research focuses on (existing) office transaction in the Dutch private equity market. Generally, transacting real estate can be divided into four stages (Crosby and McAllister, 2015; Dijkstra, 2017; Hordijk and Teuben, 2008; Just and Stapenhorst, 2018):

- *Preparation* – all property related documents needs to be collected from multiple location due to the decentralized way of working. These documents serve as input for the next phases and provide property related characteristics.
- *Marketing and pre-due diligence* – during these phases a connection between the seller and potential buyer should be made and they try to set up a head of terms (HoT).

- *Due diligence* – the process of validating all obtained information from a buyers perspective. The findings will be reported by means of risk assessments.
- *Completion* – the phase where final negotiation related to risk assessments and head of terms take place. After, approval (sale- and purchase agreement; SPA) by both parties all information and title of ownership (that serves as evidence of ownership) will be transferred.

During this process different documents of information are hand over between the involved parties. IPF Working Group (2012) defined a information checklist consisting of nine elements with various documents. Although a transaction of an office building is a process between a seller and buyer, multiple other actors – with their own expertise and value in the chain – are involved. Furthermore, from literature it can be concluded that due to multiple due diligence phases the reliability of documents and between parties is lacking. As a result, high costs and information inefficiency within real estate transactions occur, by means and perspectives.

Technology advancements, such as blockchain could be a helpful technology to overcome these inefficiency in CRE transactions and streamline the current process (Dijkstra, 2017; Deloitte, 2017; Seuren, 2018; Veuger, 2017). Based on previous studies, the next chapter discusses blockchain in more detail.

Chapter 3

Blockchain technology

This chapter aims at answering the second research question, which reads as follows: '*What is the status quo of blockchain technology in real estate?*'. To obtain knowledge about blockchain in real estate the underlying technology is elaborated according to five core components and different blockchain types (Section 3.1). Due to the immaturity of the blockchain concept 'tokens', compared to other types, Section 3.2 describes blockchain tokens in more detail. The obtained insights lead to an elaboration of the benefits and limitations of blockchain technology in office building transactions (Section 3.3). Based on blockchain technology related work, Section 3.4 visualizes the transaction process in a blockchain environment. Finally, this chapter is wrapped up in Section 3.5 with an answer second research question.

3.1 Blockchain basics

Over the past view years, blockchain technology has raised interest all over the world. Blockchain technology originated from the whitepaper: 'Bitcoin: A Peer-to-Peer (P2P) Electronic Cash System', that was published in 2008 under the pseudonym Satoshi Nakamoto[5] (Nakamoto, 2008). Nakamoto (2008) proposed a decentralized peer-to-peer (P2P) network, called blockchain. Blockchain is a technology based on distributed ledger (shared database) technology (DLT). In simple terms, 'a blockchain is a type of database that is replicated over a P2P network' (Hileman and Rauchs, 2017, p. 13). However, the definition of Hileman and Rauchs (2017) could be applied to other types of distributed databases as well. So, '*What is blockchain technology and what makes blockchain unique?*'.

Many people know blockchain as the technology behind the 'Bitcoin', a digital currency introduced by Nakamoto (2008). To understand the technology behind the 'Bitcoin', it is important to distinguish Bitcoin from the underlying technology. Bitcoin is a digital currency: a P2P electronic cash system Nakamoto (2008). This cash system utilizes a blockchain as a (transaction) ledger to record transfers of cash, in the form of Bitcoins, from one party to another (peer-to-peer), operating independently of a third party, such as a central bank. However, blockchain technology potential uses extend far beyond this digital currency (Swan, 2015). Blockchain technology is 'designed to achieve consistent and reliable agreement over a record of events, called transactions, (e.g. 'who owns what') between independent participants who may have different motivations and objectives' (Hileman and Rauchs, 2017, p. 13).

Blockchain technology has evolved rapidly over the past decade, whereby new blockchain application and types arise. Swan (2015) distinguishes three categories within the blockchain domain:

[5]Satoshi Nakamoto is the name used by the unknown person or group of people who developed bitcoin and authored the bitcoin whitepaper: 'Bitcoin: A Peer-to-Peer Electronic Cash System' (Nakamoto, 2008)

Blockchain 1.0, 2.0 and 3.0. Whereas Blockchain 1.0 is the decentralization of money and payments (e.g. Bitcoin). The second category introduces the ability to digitize contracts by encrypting (hashing) them into the blockchain, called smart contracts – self-validating and self-executing contracts (Blockchain 2.0). Finally, the third generation (blockchain 3.0) indicates the applications of the technology in real-world markets (such as real estate and supply chains). This provides a first insight in blockchain technology and its applications. In order to define blockchain technology in more detail, the technology is explained based on five core components in the next section.

3.1.1 Core components

Hileman and Rauchs (2017) and Muzammal et al. (2019) describe the typical blockchain system to its five core components: ledger, P2P network, consensus mechanism, cryptography and validity rules (Figure 5). The blockchain technology core components are elaborated below from the Bitcoin perspective (Hileman and Rauchs, 2017; Muzammal et al., 2019; Peters and Panayi, 2015; Savelyev, 2018; Spielman, 2017; Swan, 2015; Tasca et al., 2017; Zheng et al., 2017).

Figure 5: Core components blockchain technology. Source: (Hileman and Rauchs, 2017) edited by author.

Ledger. As described before, blockchain is a decentralized transparent P2P ledger - the ledger represents a list of bundled (data) transactions in cryptographically linked 'blocks'. Once the transaction data is verified a 'block' will be created. The 'blocks' in the chain are groups of transactions posted sequentially to the ledger by using a cryptographic signature ('hash', will be discussed in more detail) - that is, added to the 'chain'. Hence the name 'Blockchain'. Currently, data is centrally controlled or decentralized controlled. Blockchain it a combination of both. Data is distributed among all participants (nodes) in the network. All nodes have a version of the documents validated in the system. Hence, blockchain provides transparency in the network by its overview. Furthermore, the reliability between nodes in the network will improve due to the logg of activities.

Peer-to-Peer (P2P) Network. Hileman and Rauchs (2017) formulates a peer-to-peer network as a secured network without the involvement of trusted third party – all involved parties are directly connected in a P2P network. There is no point of single power (e.g. a party that owns the server), such as a centralized database.

Consensus mechanism. Nakamoto (2008) proposed blockchain technology as a solution for the double-spending problem. Formerly, there had to be a TTP (e.g. a bank) in transactions, which kept a ledger confirming that each portion of cash was spent only once; this is the double-spending problem. The consensus mechanism within blockchain solves this problem. Hileman and Rauchs (2017) defines the concensus mechanism as an 'algorithm that determines the ordering of transactions in an adversarial environment' (Hileman and Rauchs, 2017, p. 14). The algorithm checks all the data across the nodes in the DL. To do this the algorithm can become time consuming

and require a lot of computational power. There are different consensus algorithms according to the article of Castor (2017): 'Proof of Work'. 'Proof of Stake', 'Proof of Activity', 'Proof of Burn', 'Proof-of-Authority', and 'Proof of Capacity'. Tasca et al. (2017) discuss only three most used algorithms called '*Proof-of-Work*', '*Proof-of-Stake*' and '*Proof-of-Authority*'.

- *Proof-of-Work* (PoW) is a consensus algorithm to verify and add blocks to the blockchain by solving mathematical puzzles executed by participants in the blockchain, called 'Miners'. PoW is a consensus mechanism that is implemented in Bitcoins. Nakamoto (2008) implemented this algorithm to prevent that new Bitcoin coins can be 'made' overnight. The process for solving these mathematical puzzles is costly and time consuming due to the required computational effort. The miner, who is able to solve the mathematical puzzle, will be rewarded with a fee and his solved block with (transaction) information will be added to the blockchain network.
- *Proof-of-Stake* (PoS) is a verification method based on ownership. If a node has a certain amount of e.g. currencies, referred to as the stake, then the node is authorized to add blocks to the blockchain. In comparison to PoW the PoS mechanism does not require huge computational power, but only a private wallet that is connected to the blockchain by means of an application programming interface (API). The node with the largest stake is able to create a new block. Nodes holding get a transaction fee for creating and validating a new block. This is in contrast to the PoW principle where nodes get rewarded when forging blocks.
- *Proof-of-Authority* (PoA) is mostly used in private networks. PoA is a modified form of PoS where instead of stake with the monetary value, a validators identity performs the role of stake. Some nodes are allowed by authorization to add new blocks to the blockchain.

Validity rules. The validity rules are related to the consensus mechanism. As mentioned before, a set of rules is required within the distributed ledger which decides when and how a ledger gets updated, a transaction is marked as valid, et cetera. The validation rules could be described as the rules that participants in a blockchain follow.

Cryptography. Traditionally, trust is provided by TTPs, but within the blockchain technology it is provided through encrypting data (e.g. a piece of text). The method for encrypting and decrypting unencrypted data through a mathematical algorithm is called cryptography. In the blockchain technology encrypting unencrypted date is applied in several ways, like digital signatures and hashing.

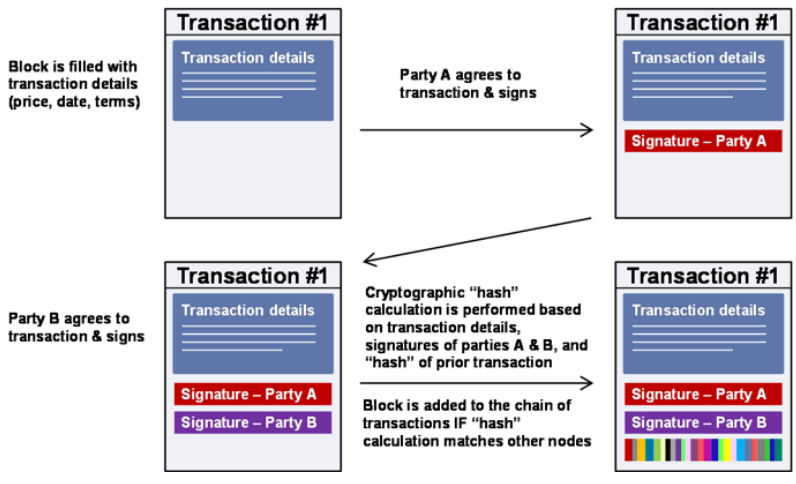

Figure 6: Visualization of cryptography within a 'block'. Source: (Schneider et al., 2016, p. 8)

As visualized in Figure 6, a transaction on a blockchain is filled with transaction details. The block on the ledger, consisting transaction information, is digitally signed (private/public key) by both parties - involved actors. As the term suggest, a digital signature that could be linked to an identity is an equivalent of handwritten, but make use cryptography principles. The signature proves that parties agree with the transaction. Cryptography is used in blockchain to store and transact information. The code which will be formed is only accessible with a private key. A private key is a large and highly random number (e.g. 4d619861aae163c2cd9641cb25e05159). However, a public key can be shared with other people and parties in the network.

After confirming the transaction information by a digital signature, the created block is added to the previous block with information. The blocks on the ledger are grouped together and tied to all previous transactions using a cryptographic technique called 'hashing' (Swan, 2015). Hashing is used to make the blockchain ledger tamper-proof, by which blockchain distinguishes itself. The hashing procedure takes the list of transactions of a new block and turns it into a unique code, a 'hash' (Savelyev, 2018, p. 554). In the context of cryptocurrencies, an algorithm, called SHA-256, convert transaction information in a code with a fixed length. In a more concrete example, take a series of letters of an unknown length. After hashing, a hash code with a fixed length will be the output. Whether the input is a few letters, a word, a sentence or a book, the output will always be a hash code with a fixed length (hashing 'tokenization' result in the following hash code: 4d619861aae163c2cd9641cb25e05159). Whenever a change in the hash is made, the outcome of the hash changes completely – a non-compliant hash will be found. As mentioned before, hashing will make the block X+1 tamper-proof which is the result of inserting the previous hash code of block X in the header, as is simplified visualized in Figure 7. The hashing mechanism can be structured by means of a 'merkle tree', what forms the underlying structure of a blockchain database and allows efficiency and secure verification of content of data. The hashing mechanism contributes to the reliability within the blockchain ledger.

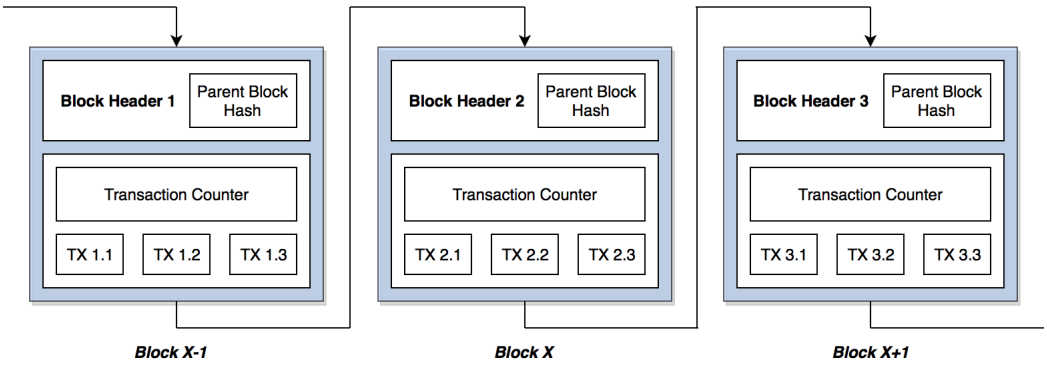

Figure 7: Connecting block's with hashing codes. Source: (Zheng et al., 2017, p. 558) edited by author

3.1.2 Blockchain types

In addition to the five core components of blockchain stated by Hileman and Rauchs (2017), they add (often conflicting) categorizations of blockchain types: permission model, smart contracts, and blockchain tokens. A blockchain token is a relatively new concept within blockchain technology. Due to the immaturity, Section 3.2 will discuss this concept and practical applicability in the real estate sector in more detail. First, the more standard categories – permission models and smart contracts – will be discussed.

Permission model. According to Peters and Panayi (2015) 'authorization within a blockchain is required for network nodes which act as verifiers, and whether access to the blockchain data itself public or private' (Peters and Panayi, 2015, p. 5). Within the permission model (read and write

access) there are different categorizations: permissionless & permissioned blockchains and public & private blockchains. Peters and Panayi (2015) outlines the categories as follow:

- *Permissionless blockchains*: anyone can participate in the verification process – no prior authorization is required – and a user can contribute his/her computational power, usually in return for a monetary reward.
- *Permissioned blockchains*: verification nodes are pre-selected by a central authority or consortium.
- *Public blockchains*: anyone can read and submit transactions (write) to the blockchain.
- *Private blockchains*: permission is restricted to users within an organization of group of organizations.

'Write' access include the authorization of who can contribute to the DL, which could be linked to the permissionless and permissioned categorizations mentioned before. *'Read' access* include the authorization of who is permissioned to see the information (or a fragment of the information) on the blockchain, which could be linked to the public and private categorizations mentioned before. The public and Private blockchain types are outlined in more detail in Figure 8.

Blockchain types			Read	Write	Commit
	Open	*Public permissionless*	Open to anyone	Anyone	Anyone*
		Public permissioned	Open to anyone	Authorised participants	All or subset of authorised participants
	Closed	*Consortium*	Restricted to an authorised set of participants	Authorised participants	All or subset of authorised participants
		Private permissioned ('enterprise')	Fully private or restricted to a limited set of authorised nodes	Network operator only	Network operator only

Figure 8: Main types of blockchains segmented by permission model. Source: (Hileman and Rauchs, 2017, p. 20)

Smart contracts. Blockchain 2.0, is the next generation in blockchain technology (Buterin, 2009). Basically, a smart contract is a deterministic computer program that is replicated and executed on a blockchain. A computer program is deterministic if, given a certain input (X) and certain initial values, it will always generate the same output (Y). Crosman (2018) stated that smart contracts are made through a self-executing computer code that automatically implements terms of an agreement among multiple parties. Unlike the name suggests, a smart contract does not necessarily create or execute a contract (in legal sense). With a collection of interacting smart contracts and oracles in a DLT context, a business process across different entities can be managed.

An oracle is a party (or a technical source such as a database, or a person who is assigned that role) who plays the role of 'source of truth' for a smart contract. The other parties who use the smart contract trust that the oracle will provide the correct data for the execution of the smart contract but cannot verify on-chain that this was actually the right data. The role of an oracle is reminiscent of a 'TTP'. However, an oracle can only be a data source, and is not involved

in the execution of the relevant contract. Furthermore, an oracle itself did not need to know about the further use of the supplied data. Commonly-trusted institutions (e.g. ABN AMRO, Rijkswaterstaat, etc.), could supply digitally signed data feeds that are used by oracles in various blockchains for example take care of automatic insurance, but as indicated above, a designated person with the correct authority could also fulfill this role.

As stated above, smart contracts can also be used to transfer value (symbolic or not). Insofar, as a payment is made with cryptocurrencies, these can be 'locked' in a smart contract, until it has been established that the conditions for the payment have been met, or a certain period has expired, so that the amount invested will become liquid again. In certain cases, token related smart contracts may even be conditional to the actual exercise of a right. Goldin Peiser & Peiser (2018) quote as example of smart contracts in the real estate industry automatic lease deals. The smart contracts mean that every step is automated, from validating loan eligibility to making payments. Smart contracts can be seen as a live contract, which can be can be initiated, authenticated and audited at any time and anywhere in the world (Goldin Peiser & Peiser, 2018).

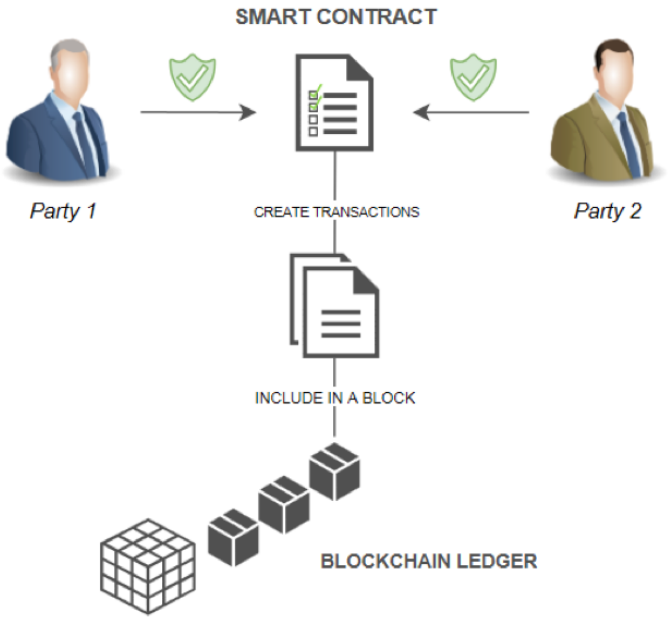

Figure 9: Smart contract flow

Mik (2017) stated that the smart contracts, as defined before, can streamline current business process (with or without the use of oracles), and therefore reduce transaction costs and time. However, there are some technical limitations of smart contracts. The most important one is that oracles are neither trustless nor decentralized. So, it is necessary to find a trustworthy and reliable oracle (or network of oracles) where all parties in a smart contract on agree beforehand. In effect, the nature of blockchain (without a trusted party) is easily lost due to off-chain events. However, the legal analysis of smart contracts is rendered difficult by the fact that the phenomenon originated in technical writings, which are characterized by an inconsistent and incorrect use of legal terms. Furthermore, due to the complexity of the technologies underlying smart contracts it is also difficult to evaluate many claims concerning their actual capabilities and real potential to change the commercial and legal landscape.

3.2 Blockchain tokens

The process of acquire blockchain tokens is called 'tokenization'. Tokenization is one of the blockchain technology types mentioned by Hileman and Rauchs (2017). This research focuses on the tokenization of an office building, therefore the blockchain type tokenization is explained in more detail. Before considering tokenization of an office building – categorized as real-world asset tokenization – a short description of what is mend by blockchain tokens, its general characteristics, benefits and limitations is given.

3.2.1 What are blockchain tokens?

The term tokenization is frequently used in publications relating to blockchain. However, there is still no generally accepted definition of a token in blockchain context. To understand tokenization, it is necessary to describe what is mend by a 'token' in blockchain context. Savelyev (2018) generally defined the concept of the token within the context of blockchain, based on the definition within the field of consumer credit arrangements, as 'a kind of a digital asset, which exists in the blockchain ecosystem, and is bundled with the right to use it.' (Savelyev, 2018, p. 864). Vidal (2017) describes tokenization, within the field of data security, as 'the process of replacing data with unique identification symbols that retain all the essential information about the data without compromising its security' (Vidal, 2017). In other words, tokenization is the method to breaking a data stream of text (information package) up into parts, called 'tokens'. The probable effect of a tokenization economy is convincingly (Chen, 2018).

	Without Tokens	With Tokens
Fundraising	• Entrepreneurs may raise funds from angel investors or venture capitalists. • Entrepreneurs may raise funds from the general public through crowdfunding.	• Entrepreneurs can raise funds directly from investors across the globe. • Entrepreneurs can raise funds from the general public through initial coin offerings.
Investing	• Average investors have few opportunities to invest in promising early-stage ventures. • Investors have limited liquidity with private company investments.	• Average investors can have almost equal opportunities to invest in early-stage ventures across the globe through blockchain tokens. • Investors enjoy almost immediate liquidity with blockchain tokens.
Community Building	• Platforms may start to appeal to users when they enjoy strong network effects. • Platforms may start to appeal to complementors when they enjoy strong network effects.	• Platforms can reward early adopters with tokens, compensating for the lack of network effects. • Platforms can reward early complementors with tokens, compensating for the lack of network effects.
Open Sourcing	• Open-source projects may fund their continued development through donations. • Open-source projects usually do not share their success with core developers.	• Open-source projects can fund their continued development through token sales. • Open-source projects can share their success with core developers through tokens.

Figure 10: Potential of blockchain tokens. Source: (Chen, 2018, p. 22)

When discussing tokenization, it is important to define the nature of the underlying digital assets of the token. 'Is the asset native on the chain or is the asset a digital representation of an existing off-chain asset?' (Hileman and Rauchs, 2017, p. 64). A stock is currently issued digitally (on-chain) and its existence is defined by the network. According to Hileman and Rauchs (2017) a token is an

off-chain asset that is digitized and represented in a distributed ledger network. In effect, almost any object or a right can be tokenized, traded and digitally registered on a distributed ledger (Hileman and Rauchs, 2017; Savelyev, 2018). Tokens are categorized according to the taxonomy of Hargrave et al. (2018):

- *Money tokens* (Bitcoin & Zcash), used to buy and sell real-world goods
- *Platform tokens* (Ethereum, Binance & OmiseGo), used as a 'payment' to run transactions on a blockchain platform
- *Utility token* (Storj & ARK), application in the form of a digital service mostly running on a platform token. These tokens can be compared to API keys, used to access the service.
- *Security tokens* (Polymath & Harbor), tied to an underlying physical asset (real estate, art, commoditys etc.),

Blockchain technology, defined in Section 3.1, allows users to store and transfer ownership of these tokens, since blockchain offers features such as decentralized ownership and control, novel consensus mechanisms, immutability of data, trustless protocols and new governance models. While there are a wide range of use cases, all tokens represent decentralized ownership of some underlying value. Indeed, it is likely that we are entering a new 'tokenized economy', where investors will be able to buy fractional ownership of any asset of value, from sports teams to cities and governments, with each transaction recorded on blockchain technology (Hargrave et al., 2018; Levin, 2018). For this research the underlying value of tokens is considered as assets of known value, within the domain of security tokens. Assets of uncertain value and new tokenized assets are not taken in consideration.

3.2.2 Real-world asset tokens

A real-world asset token is a representation of an underlying physical asset - where the approximate price is known (e.g. real estate, art, gold, etc.). In this research the underlying physical asset is an office building (e.g. real estate). A hypothetical example of asset tokenization, suppose there is a $1.2 million worth office building. Tokenization can transform this office building in 20 tokens (the number is totally arbitrary). Each token is a representation of 5% share (worth $60,000) of the underlying asset.

$$Value\ of\ one\ token = \frac{Total\ value\ of\ the\ underlying\ asset}{Number\ of\ tokens\ outstanding}$$

The 20 tokens can be issued on a platform, for example on Ethereum. If a party buys one token, the party buys actually 5% of ownership rights of the underlying asset.

> 'Tokenizing real-world assets will always require off-chain processes'.
> *(Hileman and Rauchs, 2017, p. 64)*

In this case, tokenization, with as underlying physical asset real estate, is a method to convert ownership rights of an asset into a digital token and forms a digital representation of a building on a blockchain. Due to the off-chain process of real-world assets distributed ledgers itself cannot verify external data that is added to the ledger. Distributed ledgers are only able to manage (store and transact) data of the record of ownership. However, if documents are standardized and digital requirements are developed, API's could theoretically validated information in a distributed ledger. In other words, putting external data of a building in a distributed ledger requires trusted participants who provides accurate and correct data.

Additionally, tokenization of an office building is most suitable within the domain of a digital permissioned decentralized network. In Section 3.1.2 oracles in a smart contract are described

as an external party who plays the role of 'source of truth' for a smart contract. Oracles are neither trustless nor decentralized. So, it is necessary to find a trustworthy and reliable oracle (or network of oracles) where all parties on agree beforehand in order to determine which information is right. According to Hileman and Rauchs (2017) it is likely that oracles – the source of truth within the blockchain network – is delegated to collaborations of parties in a sector or service providers, called validating nodes. These validating nodes (TTP's) guarantee the quality of data input. Hence, without standardization of documents and taxonomy trusted parties are still needed to guarantee quality. This means that introducing blockchain tokens in non-digital assets require off-chain processes (Hileman and Rauchs, 2017; Hargrave et al., 2018).

3.2.3 Blockchain tokens in practice

Due to the immaturity of tokenization in all sectors, applications and platforms are generally still in Proof-of-Concept stages and have not formally launched (Levin, 2018). Wu (2018) outlines some examples of tokenization of real-world assets: Royal Mint Bullion (Gold), Chronicled & MediLedger (Supply Chain for Pharmaceuticals), Blockfreight (Cargo Shipments) and CODEX (Art & Collectibles). More specific examples in the real estate sector are SwissRealCoin, Bloqhouse, BankEx, Brickblock and Propy. Some of them are elaborated below.

- *Brickblock* is a blockchain project that attempts to bridge blockchain technology and cryptocurrency with real-world value on the base of an exchange-traded fund (ETF). ETFs tracks and index of multiple underlying assets, these assets could be stocks, bonds, commodities (such as gold or silver) or real estate. With one ETF share you own multiple assets. For example, the AEX ETF aggregates shares of the 25 biggest companies in the Netherlands in one tradable security. An owner of a AEX ETF is entitled to a proportion of the profit of each company within the ETF. The problem with investing in ETFs is that the brokerage fees are relatively high for small transaction and difficult to buy for non-institutional investors. Brickblock tackles this problems by tokenization of ETF shares. Through its smart contract platform, Brickblock allows users to invest in and sell tokenized assets, or assets represented and backed by Brickblocks Proof of Asset (PoA) tokens. For example, users can invest in tokenized real estate assets and be entitled to profits, such as rents, dividends, and asset appreciation.
- *Bloqhouse* is another example of a blockchain financial technology company that developed a secondary marketplace that is capable to allow tokenization and trading real assets holding. A similar real estate tokenized solution is the *SwissRealCoin* (SRC) founded by a team of real estate professionals in Switzerland.

According to the above described application, blockchain tokens within the real estate sector can be defined as a share of its economic value: 'A digital representation of the economic value with as underlying asset real estate'.

3.3 Benefits and limitations of blockchain technology

Blockchain technology and its corresponding applications are hyped. According to literature blockchain has, among other things, the potential to change the way people invest in real estate. However, blockchain tokens and its corresponding technology is subject to a complicated web of legal and practical issues. The five core components of blockchain – as elaborated in Section 3.1 – and corresponding applications (smart contracts and blockchain tokens) entails several potential benefits – and associated challenges. This section discusses the most important benefits and challenges of the use of this technology in the real estate sector. Based literature the following benefits and challenges towards the implementation of blockchain technology (e.g smart contracts and blockchain tokens) are defined (Buterin, 2009; Dilendorf and Khurdayan, 2018; HEYI Blockchain, 2018; Hileman and Rauchs, 2017; Ølnes et al., 2017; Swan, 2015).

Main benefits blockchain technology
The implementation of blockchain technology has the potential to turn the real estate ecosystem into a market which is more compared to the financial market. Blockchain could have a major effect on asset trading (HEYI Blockchain, 2018). Therefore, the implementation of this technology should be analyzed. Some of the benefits are presented below.

- *Transparency.* One of the main benefits of blockchain technology is transparency. Transparency is the result of democratizing access to data. History of transactions remains visible and every nodes has complete overview of transactions (Ølnes et al., 2017, p. 359). In addition, transparency increases the reliability of the network due it record-keeping and validation methods. All validated information is visible for all involved nodes. Furthermore, activities of stakeholders can be traced by making use of authorization in the system. This makes blockchain technology an interesting technology in various data management processes.
- *Automation.* Standardization of contracts (smart contracts), described in Section 3.1.2, provides automation of settlements of contracts. Manual tasks can be omitted and paperwork reduced what result in reducing costs and speeding up processes.
- *Security.* Other advantages of DLT is the security as a result of traceability. Within the blockchain network no one person, group, or organization controls the network. In addition, blockchain rely on advanced cryptography to provide security to users. Each user has his or her own private key (Section 3.1.1) that allows access to his or her blockchain assets/specific documents.
- *Immutability.* After a transaction of information has been recorded and confirmed (validated) on the blockchain, it essentially cannot be changed. Due its hashing structure blockchain technology avoids fraud and manipulation (unauthorized changes).
- *Liquidity.* Liquidity refers to the ease with which an asset can be bought or sold. Only $7.3 trillion of the $228 trillion in total global real estate assets was exchanged in 2017. Furthermore, due to its characteristics (Section 2.1) real estate is seen as illiquid. However, blockchain tokens could improve the liquidity due to increase of investors, reduce cost of entry and standardized transactions.
  - *Increase of investors.* With tokenization, the pool of potential investors is truly global. Anyone with sufficient capital and an internet connection can easily participate in buying, holding and selling real estate located anywhere.
  - *Reduce cost of entry.* What counts as 'sufficient capital' will also change when real estate is tokenized. A token does not necessarily have to be sold as a whole unit. Instead, the code underlying the token may permit it to be subdivided, allowing the issuer or subsequent holders to sell fractional tokens at lower prices due to fractionalization. This opens the market to smaller investors who could not otherwise participate and enables greater opportunities for diversification for wealthier investors.
  - *Standardized transaction.* Thanks to the blockchain technology on which tokenization is built, the purchase and sale of real-estate tokens can be implemented using standardized smart contracts, which do not have to be individually negotiated and the terms of which are implemented automatically, reducing transaction costs.

Main challenges blockchain technology
A new technology, such as blockchain and its applications, introduces certain challenges and many of which are currently not solved. Some of the challenges that raise are discussed below.

- *Regulations.* Due to the immaturity of blockchain technology (e.g. smart contracts and blockchain tokens) neither a country or government has a solid regulation (Swan, 2015). For example, if tokens representing economic ownership what happens if a company that trade in blockchain tokens sells the property? Currently, companies are not protected by the law

when selling a property with blockchain tokens. Therefore, countries needed to change their law to enable these new business models 'enablers'.

- *Trusted third party.* The idea of Blockchain DLT and smart contracts is to create a trustless environment Nakamoto (2008). While this is possible to achieve when the underlying asset is digital (on-chain processes), within real estate transactions this is not the case (off-chain processes). Therefore, centralization in the form of a TTP (oracle) is needed. In general, the connection of a TTP is required when a blockchain network interacts with real-world assets. For transacting real estate external data is needed. A TTP provides information about the accuracy and correspondence to the data that it supposed to represent. DLT is not able to verify external data in the ledger. However, it provides information about the proof of the record of ownership of the data within the DL. So, it is the responsibility of the participants within the DL that the data is accurate and correct. Hileman and Rauchs (2017) stated that it is plausible that service providers will act as a TTP for guaranteeing data quality.
- *Lack of standardization.* Within a blockchain network all parties are using the same data formats and taxonomies. In case of real estate transactions parties are using their own systems, data formats and corresponding taxonomies. This might lead to barriers when current processes will be implemented in a blockchain network. Agreements from all participants are needed to create the same formats and taxonomies. Additionally, the interoperability between a DL and current systems is difficult due to the lack of standardization.
- *Security.* Data in the DL is only accessible for participants using a personal decryption code key (Section 3.1.1). However, these decryptions codes could be easily shared (e.g. e-mail), stolen or lost. Participants without granted authority are able to access the confidential data with the shared, stolen or founded decryption code.

3.4 Blockchain based transaction process

The previous Chapters discusses the basics of blockchain technology, blockchain tokens and the consequential benefits & challenges. Based on the acquired knowledge a visualization of the transaction process on a blockchain can be formed. The phases within a blockchain transaction are often discussed (Nakamoto, 2008; Botjes, 2017; PWC, 2018; Gupta and Sadoghi, 2018; Blockgeeks Inc., 2018). According to this literature the overall steps are as follow: (1) Someone requests a transaction. As mentioned before, a transaction refers to the exchange of data between (two) parties. Data could represent money, contracts, real estate, art, or any other asset that can be described in a digital form. (2) The transaction data is sent to all participants (nodes) in the specific blockchain. (3) The nodes – every computer in the network – determine if the transactions are valid based on a set of validation rules that the network has agreed to. (4) After confirming the transaction information by a digital signature, the created block is added to the previous block with information. The blocks on the ledger are grouped together and tied to all previous transactions using a cryptographic technique called hashing (Figure 7). The sequence of linked hashes creates a secure, independent chain. (5) The new block is added to the existing blockchain. When a block is validated and hashed the data within the block is immutable and auditable. (6) Now the transaction is part of the blockchain and cannot be altered in any way. The transaction is complete. A simplified visualization of this process is given in Figure 11.

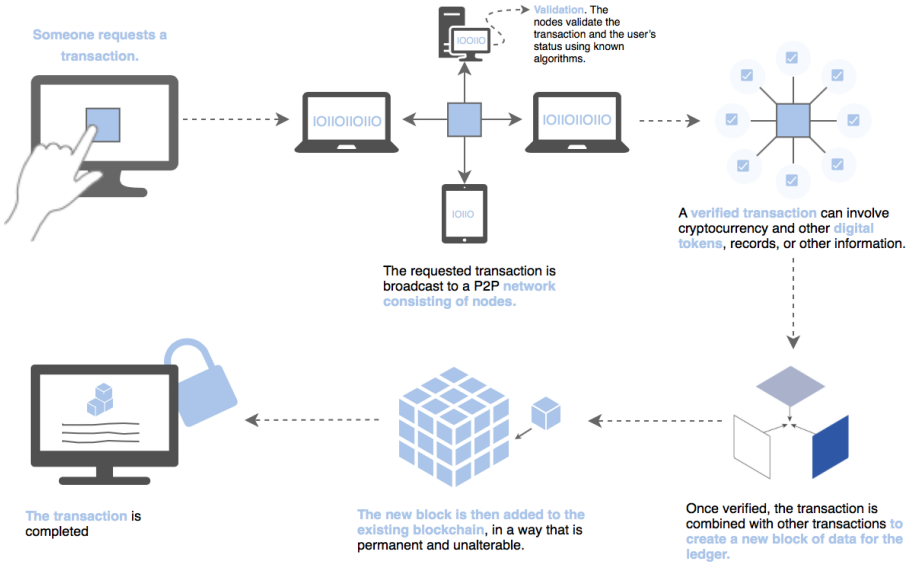

Figure 11: Visualization of blockchain technology transaction. Source: (PWC, 2018) edited by author.

3.5 Summary

Based on recent literature regarding blockchain technology, the second research question can be answered: '*What is the status quo in regard to blockchain technology in real estate transactions?*'.

Over the past view years, blockchain technology has raised interest all over the world – mainly as the underlying technology of Bitcoin (Nakamoto, 2008). A blockchain distributed ledger is simply a new way of managing data and consists of five core elements (Hileman and Rauchs, 2017; Seuren, 2018; Tapscott and Tapscott, 2016; Tasca et al., 2017):

- Ledger
- Peer-to-peer (P2P) network
- Consensus mechanism
- Cryptography
- Validity rules

Blockchain technology relies on (1) *distributed ledger technology* – a shared ledger between all parties in the network. In this (2) *network* Peer-2-Peer (P2P) transactions – without the need of validation by a TTP – could be made between two or more parties, also referred to as nodes. Transactions in this P2P network are validated according to the standards of a specific (3) *consensus mechanism* (e.g. PoW, PoS, PoA, etc.). A consensus mechanism is an authorization method that allow some nodes to create new blocks – validation of transactions. For example, the PoA consensus mechanism enables nodes to use their 'authorization' rules to create new blocks in a secured way Hileman and Rauchs (2017). To reach consensus, participants in a network must be able to trust each other. Within a blockchain network trust is created by (4) *cryptographic proof*. Once the transaction is verified. The transaction is combined with other transactions and added to the chain of blocks, which is called a 'hash'. The chain of blocks is structured by means of a merkle tree. If a block is (5) *validated* and hashed (applied cryptography) the data within the block is immutable and auditable. The transaction in the blockchain is complete (Figure 11).

Based on these five core elements various blockchain network types can be distinguished and application arise, such as, permission models, smart contracts and blockchain tokens. First, when designing a blockchain network it is important to determine authorization rules. To set authorization rules the *permission model* is used. Authorization rules in blockchain network are required to determine whether access to the data in the network is public or private, and which nodes will act as verifiers: '*Who is able to read and write*'. Besides, network types, blockchain technology applications arise. One of the most known applications of blockchain technology are *smart contracts*. Smart contracts are self-executing computer codes that automatically implements terms of an agreement among multiple parties. Unlike the name suggests, a smart contract does not necessarily create or execute a contract (in legal sense). An example of smart contracts in practice is LegalThings, standardized and digitized real estate agreements on a blockchain. Another application within blockchain technology is explained in more detail, due to the immaturity of the application: *Blockchain tokens*. Blockchain tokens are a new phenomenon in transacting real estate. The process of obtaining blockchain tokens is called 'tokenization'. Tokenization is the method to break a data stream of text up into parts. A real-world asset token is a representation of an underlying physical asset (object). From applications in practice it can be concluded that the implementation of blockchain tokens in real estate mainly rely on shares of holdings and not direct equity transactions. Thus, it can be assumed that blockchain tokens are a representation of the economic value of a specific object and not an overall representation of a object. The main advantages of implementing blockchain technology and more specific tokens in digital transaction processes are: liquidity, transparency, automation and security.

However, some challenges arise as well. Although blockchain technology enables transacting information in a network without the use of TTPs, putting external data of a building in a distributed ledger requires trusted participants who provides accurate and correct data. Distributed ledgers itself cannot verify external data, also referred to as off-chain data, that is add to the ledger; DLT is is an interesting technology for data management based on a proof of record of ownership. Therefore, it is plausible that service providers will act as a TTP for guaranteeing the data quality (distributed ledger input). Other more specific challenges of implementing blockchain technology in real estate are related to regulation, standardization and security.

Blockchain and its deriving applications, e.g. smart contracts and blockchain tokens, could support and enhance the reliability, efficiency and security of data transferred among a network. Therefore, blockchain technology features seem to provide a solution that could enhance the transaction of office buildings. The aforementioned blockchain features sketch out the fundamentals and current development of blockchain technology. These features can be used to support and streamline transactions in CRE.

Chapter 4

Research methodology

Literature in Chapter 2 and 3 forms the theoretical framework of this research. The framework is related to the office transaction process, as well as the status quo regarding blockchain technology. The objective of this research is to describe and visualize the implementation of blockchain technology in the transaction process of office buildings. This chapter extensively discusses the research approach to answer the main and other research question. The first section of this chapter describes the general research approach and design. In Section 4.2 and 4.3 the methods and tools that will be used are elaborated. Based on the discussed research method, design and tools the research will be carried out.

4.1 Design science research

As mentioned before, the aim of the research is to provide a solution for the implementation of blockchain technology in the real estate transaction process of an office building. First, a literature study is conducted to get a comprehensive overview of scientific research regarding the current situation. Currently, blockchain technology is known as a technology that is able to solve everything, but often the problem is unknown. To answer the research question: '*How to implement blockchain technology to enhance a real estate transaction of an office building?*' besides the theoretical framework in-depth knowledge regarding pain points that occur during the current transaction process is needed – to analyze the enhancement of blockchain technology. Hence, the research could be elaborated into two general phases: (1) research according to the current transaction process, with the aim to identify pain points and (2) research according to a solution with an underlying blockchain technology. Combining both elements will result in a blockchain based solution what enhances the current transaction process of an office building.

Identifying pain points and answering the main question various research approaches could be used. Williams (2017) stated that in the research domain three main approaches can be outlined: (1) quantitative research, (2) qualitative research, and (3) mixed methods. A quantitative research approach requires numerical data and is most suitable for statistical analyses. In contrast to quantitative research, a qualitative approach requires textural data (Williams, 2017). As described in Chapter 1 this research deals with a complex and relatively new subject. Although, recent studies focus on the applicability of blockchain technology in real estate management and -transactions, research regarding implementation of blockchain technology in the real estate transaction process remains. The aim of this research is to implement blockchain to enhance the current transaction process. Before proposing a blockchain application the research should focus on obtaining more knowledge regarding pain points in the process. Since, this research focuses on the enhancement of the current transaction process. Hence, a qualitative research with relatively unstructured ap-

proach will be most suitable for this research to identify pain points in the current process – to gain more knowledge and understanding regarding the transaction process.

In addition, Baarda et al. (2013) distinguishes three types of qualitative research: (1)testing, (2)exploring, and (3)describing. To gain more in-depth knowledge about pain points during the transaction process, research with an explorative nature is preferred (Baarda et al., 2013). A characteristic of explorative research is to gain more (in-dept) knowledge and understanding about subjects where little research is available or more in-depth knowledge is preferable. It provides significant insights, but will not come up with final answers for decision making. This research will have an explorative nature because there is more in-depth knowledge needed regarding pain points that occur during the transaction process to provide a subsequent solution. Therefore, a explorative qualitative research is preferred.

The above described research design could be linked to 'Design Science Research'. Design science research, as conceptualized by Simon (1996), 'is based on pragmatic research and aims to create an innovative 'artefact' that will help to solve real world-problems' (Hevner and Chatterjee, 2010, p. 9). For this reason, it is highly relevant to information system research. Design science research is applied in researches that focus on developing design propositions for a field problem – the cumbersome CRE transaction process. The research starts with a review of existing literature(systematic review) of a specific issue, to be followed by a synthesis of design propositions. According to Aken van and Romme (2009) the literature review and synthesis can produce design propositions to be developed further, but can also uncover gaps in the existing literature (Aken van and Romme, 2009, p. 9). The research starts with a systematic review of previous work on real estate transactions and blockchain technology. However no design concepts are found as existing work is not established or developed enough. Therefore, the research focuses on the identification of pain points within the current transaction process (research synthesis).

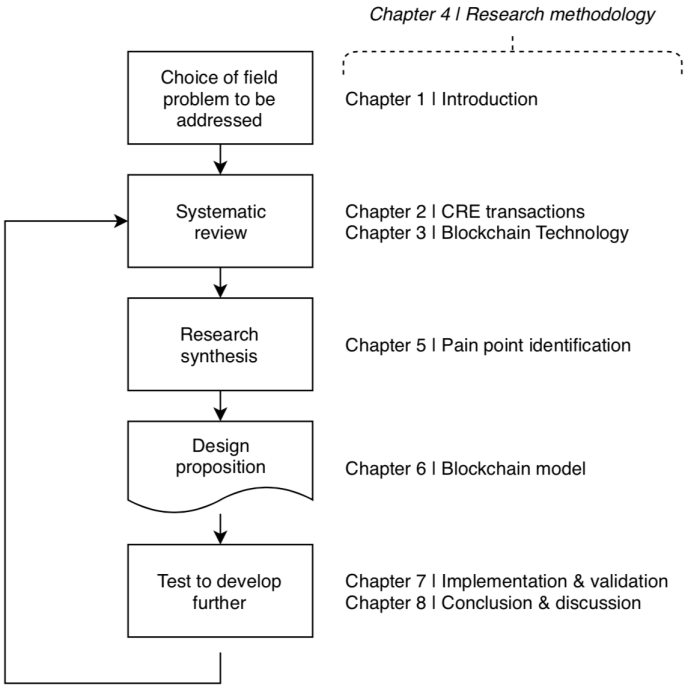

Figure 12: Design science research cycle. Source (Aken van and Romme, 2009, p. 10) edited by author.

4.2 Research method

During literature research general challenges related to commercial real estate transaction processes are found. To identify the pain points – occur in the current transaction process of an office building – in-depth knowledge is needed, besides the scientific knowledge obtained during literature research (desk research). This section comprehensively describes the data collection method that should be used to identify specific pain points in the current transaction process of an office building.

4.2.1 Empirical research

According to the literature of Baarda et al. (2013), Bryman (2012) and Williams (2017), a research with an explorative character with qualitative nature is most suitable for this research. Baarda et al. (2013) elaborate three most commonly used research methods:

1. *Existing documents*. Obtaining data from previous events.
2. *Interviews*. Obtaining data for in-dept knowledge or subjects with limited scientific knowledge.
3. *Observations*. Obtaining data for analyzing behaviour of participants.

For answering the main research question, in-dept knowledge of a relatively unknown subject is needed – based on experiences of the participants. Therefore, interviews are the most suitable method of data collection. In the interview domain Baarda et al. (2013) make a distinction between individual interviews and group interviews. To obtain in-dept knowledge, opinions and experiences regarding pain points in real estate transactions the most appropriate way of interviewing is individual. Furthermore, Baarda et al. (2013) divides structured and semi-structured interviews. Semi-structured interviews is a method with fixed topics and open questions. In this way participants are able to share their knowledge about the specific topic (Baarda et al., 2013). Semi-structured interviews have the possibility of adjustment and create flexibility during interviews. Therefore, the qualitative approach with semi-structured interviews is most appropriate for this study.

As described before, the research could be elaborated into two different phases (Section 4.1). Hence, multiple interview rounds are used to propose an optimal solution. First, to gain in-dept knowledge about pain points that occur during transaction a semi-structured interview session is held (Round I). After developing a blockchain model, the model is presented to the same participants for validation (Round II). Both, 'Round I' and 'Round II' are elaborated below.

Round I
During the first round interviews of this research, the respondents are confronted with a semi-structured interview regarding pain points in the current transaction process. Some literature related to the Delphi method refers to open-end or close-end questions to determine the relevance of the issues or to categorize aspects. Due to need of in-dept knowledge, experiences and opinions of individuals regarding pain points that occur in transacting offices semi-structured questions are appropriate. With a semi-structured interview some topics are fixed and the interviewee is able to obtain in-dept knowledge on the specific topic by discussing the topic with the respondent. In this way knowledge will obtain regarding pain point during the transaction process of an office building.

Round II
During the second round interviews of this research, the interviewees (Round 1) are asked again to pragmatically validate the proposed model. To properly reflect on the proposed system, an user interface will be created (Section 4.3.3). The aim of the second round is to validate the proposed model and gain knowledge regarding challenges. Hence, this round will consist of semi-structured interviews as well.

Respondent selection

The experts interviewed during this research are also referred to as participants. In Section 2.2.1 the actors in the process are described. Due to aim of the interviewees chosen participants have knowledge regarding the transaction process of an office building. The solution will be proposed by the researcher, based on his knowledge and an off-record expert discussion. During Round II, the proposed solutions will be presented to the same participants. It is not expected that participants have specific knowledge regarding blockchain technology.

The method for selecting participants is called 'purposive sampling' (also known as judgment, selective or subjective sampling) (Baarda et al., 2013). Purposive sampling is a non-probability sampling method by the judgment of the researcher. During the transaction process multiple actors are involved (Section 2.2.1). The participants of the interviews belong to one of the 'actor categories' mentioned in Section 2.2.1. The visions of those participants will give a comprehensive answer to the pain points that occur during the transaction process. According to Hennink et al. (2011) the number of participants in a qualitative research is enough when the collected information starts to repeat itself. This is referred to as saturation. The next section discuss the method for analyzing the obtained data.

4.2.2 Grounded Theory

To manage and streamline the obtained data from the semi-structured interviews of Round I and II (Section 4.2.1) the Grounded Theory (GT) will be applied (Figure 13). The GT is defined by (Strauss and Corbin, 2015). Charmaz (2006) stated that Strauss and Corbin (2015) aimed to move qualitative inquiry beyond descriptive studies into the realm of explanatory theoretical frameworks, thereby providing abstract, conceptual understandings of the studied phenomena (Charmaz, 2006, p. 10-11).

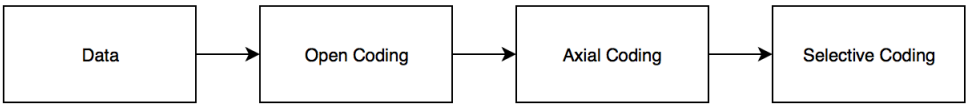

Figure 13: Grounded theory

The interview transcripts form the input for the grounded theory. However, only relevant parts of the transcripts are coded (e.g. not the background of the respondents). Based on this data there are different kinds of coding methods that can be used. The used coding methods are elaborated below (Bryman, 2012; Charmaz, 2006; Strauss and Corbin, 2015).

1. *Open coding*: the process of breaking down, examining, comparing, conceptualizing and categorizing data (Strauss and Corbin, 2015, p. 61) . Open coding is the first step in streamlining the obtained data. Each text fragment – in the transcript – is coded. The label is a representation of the information of the text fragment. the open coding phase result in a 'longlist' of summarizing codes.

2. *Axial coding*: is a set of procedures whereby data are put back together in new ways after open coding, by making connections between categories (Strauss and Corbin, 2015, p. 96). Open coding result in a longlist of summarizing individual codes. During the axial coding phase these codes are categorized, which result in connections between respondents. For example, respondent can speak about the same problem but use other words to describe the problem (underlying meaning is the same). With axial coding the initial codes are split, merged, new codes are made, codes are renamed, etc. Subsequently codes belonging together are clustered under a main code.

3. *Selective coding*: is the process of choosing one category to be the core category, and relating all other categories to that category. (Strauss and Corbin, 2015, p. 116). According to

Charmaz (2006) the aim of selective coding is to create a single storyline, which helps to formulate a answer to the research questions.

The semi-structured interviews of Round I and II are analyzed based on the GT approach. The coding process is an interactive process of reading and re-reading the interview transcripts and codes. The interview transcripts are confidential and attached in the Appendix C.

4.3 Modeling

In Section 4.1 and 4.2 the research approach and method (tools) are defined. To obtain in-depth knowledge regarding pain points that occur during the current transaction process, a starting point should be determined. Subsection 4.3.1 defines the starting point for the interviews of Round I. Subsequently, a solution will be proposed and validated in (interview) Round II. The methods used for the solution and visualizing the solution are elaborated in Subsection 4.3.2 and 4.3.3.

4.3.1 Business Process Model and Notation

During literature research the current phases and tasks of the transaction process of an office building are defined. To get a better understanding, the process is visualized based on Business Process Model and Notation (BPMN) – 'The leading standard in the frame of business processes and workflow modeling languages' (Chinosi and Trombetta, 2012, p. 124). A BPMN model is designed to be readily understandable by all business stakeholders and serves as a common language, bridging the communication gap that frequently occurs between business process design and implementation (Rosing von et al., 2014, p. 429). BPMN language is chosen due to its ability to describe in detail, simulate and execute processes. By formalizing the transaction process of an office building in BPMN a simple and understandable overview of the business process is created, while providing the semantics and underlying mechanisms to handle the complexity inherent of the process (Chinosi and Trombetta, 2012; Rosing von et al., 2014). Before the interviews of Round I a BPMN is created. As a result, much more clarity and depth could be created during the semi-structured interviews – instead of a general description of the pain points that occur during this process. A visualization of the current transaction process contributes to defining the pain points in more detail. In addition it could be analyzed how the proposed solution enhance the current way of transacting real estate.

The BPMN of the current transaction process of an office building is presented in Appendix D and summarized in Figure 17. The elaboration of the BPMN could be found in Chapter 5.

4.3.2 Unified Modeling Language

Literature and empirical findings of Round I combined with the BPMN model result in a detailed identification of pain points and challenges that encounter during the process. To analyze the enhancement of blockchain technology, a solution for the defined challenges will be proposed.

For analyzing and designing a software solution this research will make use of Unified Modeling Language (UML). UML is a software modelling standard for a real or planned process. It can be examined to determine planned systems features and characteristics, but also the structure, behavior, relationship of systems elements and the purposes, architecture, and design decisions of the system in general (Chonoles, 2018b, pp. 19-21). In short, where BPMN is process-oriented, UML is oriented on the behave and structure of an object within the process. There are 14 different UML diagrams (Figure 14), which can be categorized into two categories: structure and behavior. The UML structure diagrams show the static structure of the elements of the system being modeled. Behavior diagrams show the dynamic behavior of the elements of a system. Examples of UML modeling diagrams are: Sequence diagrams (*behavior*), Activity diagrams (*behavior*), Class diagrams (*structure*), State diagrams (*behavior*).

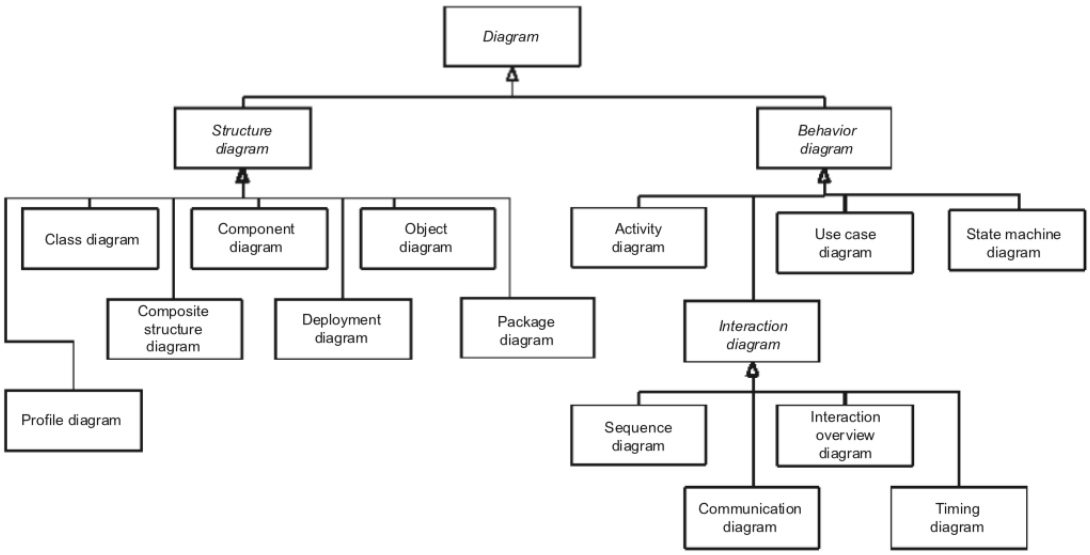

Figure 14: The taxonomy of UML diagrams. Source: (Chonoles, 2018c, p.66).

For designing the software solution the following structure and behavior UML diagrams are chosen, because these diagrams gain insight in behavior between parties in the network and structure information flows.

- *Sequence diagrams.* First, sequence diagrams are proposed to show the exchange and interplay of messages among elements (stakeholders), called an interaction (Chonoles, 2018a). Within the transaction process multiple messages, documents, agreements and other data elements are transferred between stakeholders. Sequence diagrams provide understanding of the behaviour of the different stakeholders during the process.
- *Class diagrams.* Berardi et al. (2005) consider class diagrams as one of the most important UML diagrams (Berardi et al., 2005, p. 71). After the proposed sequence diagrams, 'class diagrams model information elements and show how these elements are related to each other by organizing objects in classes' (Berardi et al., 2005, p. 71). A class diagram can be split into different classes. The classes are structured as follow: class name, attributes and operations (Figure 15).

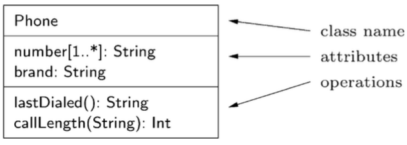

Figure 15: Class example within class diagram. Source: (Berardi et al., 2005, p. 74).

4.3.3 Prototype

In this research a software solution is proposed by analyzing and designing UML sequence and class diagrams. In order to analyze the feasibility of the proposed solutions, a user interface (UI) from a end-users perspective is created (physical interface). End-users in the transaction process can use these user interfaces to test and evaluate the proposed solution (Beaudouin-Lafon and Mackay, 2003, p. 1007). UI prototyping takes its origin from a (evolutionary) rapid prototyping approach,

(Weichbroth and Sikorski, 2015, p. 185). Involving end-users in testing and evaluating prototypes is an iterative process and offers validation of user requirements, improves the willingness to adopt the system and result in a greater frequency of contact with the end-users. According to Weichbroth and Sikorski (2015) the following two techniques are necessary for identifying required functionality of the prospective system (Weichbroth and Sikorski, 2015, p. 186).

- Drawing design techniques – expressing design concepts in the form of UML or BPMN diagrams.
- Context of use analysis – a structured description of user characteristics, task and organizational environment.

Weichbroth and Sikorski (2015) distinguished Low-fidelity (paper) prototypes and Interactive prototypes. Both mentioned perspectives can be applied at different stages of the same IT project. For visualizing the UML solution (Section 4.3.2) a low-fidelity prototype in the form of artboards (also called storyboards) is most suitable for this research. The low-fidelity prototype – *proof of concept* – is used to illustrate the designed UML based solution, to prove its value and motivate actors to implement the solution. Furthermore, the solution-orientation can be evaluated by end-users in an early stage. This leads to the improvement of the final design and it reduces the chance of necessary changes later in the process.

4.4 Summary

This design science research focuses on developing a blockchain technology application to enhance the current transaction process. This chapter discussed the proposed research approach to answer the main and other research question, which is visualized in Figure 16.

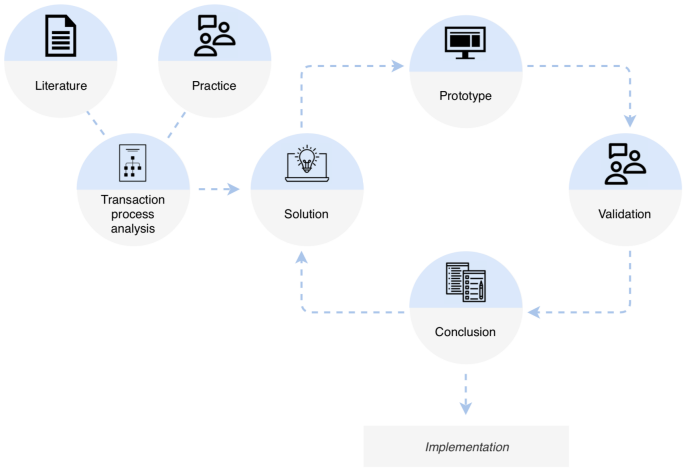

Figure 16: Research design: analysis, solution, prototype, validation and conclusion

To review the field problem, a theoretical framework of related work forms the starting point of this research. The findings of this framework are visualized in a BPMN model and combined with in-dept semi-structured interviews regarding pain points (research synthesis). From this point a concept is proposed to overcome the mentioned pain points. Based on this concept it is analyzed what blockchain features could enhance the proposed concept. To validate the proposed blockchain infrastructure a *prototype* in the form of artboards and storyboards is developed (proof of concept). These boards visualize, among other things, the user interface which enhance the validation process. After validation a *conclusion* can be drawn. On the one hand the validation results in input for optimizing the proposed model, and on the other hand it validates the proposed model for the next phase: development and *implementation* of the tool. The discussed methods and tools in this chapter are used to answer the research questions in the next chapters.

Chapter 5

Pain point identification

The literature in Chapter 2 and 3 forms the theoretical framework of this research. Based on the theoretical framework the research methodology is outlined (Chapter 4). The framework forms the input for a BPMN model to get a better understanding of the current process. The proposed BPMN model in combination with semi-structured interviews result in answering the third research question, which read as follows: '*What pain points occur during the transaction process of an office building?*'.

First, knowledge obtained in Chapter 2 – regarding the current transaction process – is visualized in a BPMN model (Section 5.1). This model describes in detail, simulates and executes the current process based on the defined four phases: preparation, marketing/pre-due diligence, due diligence and completion. From this model the pain points in the process are defined and analyzed by semi-structured interviews (Section 5.2). In this way much more clarity and depth can be created – instead of a general description of the pain points that occur during the process. Furthermore, by means of visualizing the current process, it can easily be understood how a proposed solution can fit in the current process. Finally, the chapter is wrapped up in 5.3.

5.1 BPMN model

On the basis of the theoretical framework a BPMN model is created (Appendix D). The BPMN model visualizes the process in an understandable way. The process is elaborated into four phases: Preparation, Marketing and Pre-due diligence, Due diligence and Completion. The BPMN model (Appendix D) is in a simplified way presented on the next page (Figure 17). The figure presents the phases with corresponding actions and involved stakeholders per phase. These phases form the basis for the semi-structured interviews of Round 1. During this round four semi-structured interviews are conducted with a (1) financial and technology advisor (partner), (2) Head of Investments (3) Data specialist & Real Estate advisor Capital Markets and (4) Consultant Capital Markets. The focus of the interviews mainly rely on advisors since the transaction process is often outsourced by property owners. Furthermore, advisors are involved in many different processes with multiple property owners. Although, saturation is reached after these interviews, an extra interview is conducted to obtain more specific knowledge regarding the process before the transaction process, called operating phase. Therefore five interviews are conducted to obtain specific knowledge regarding pain points in the current process. In Section 5.2 the pain points are elaborated in more detail.

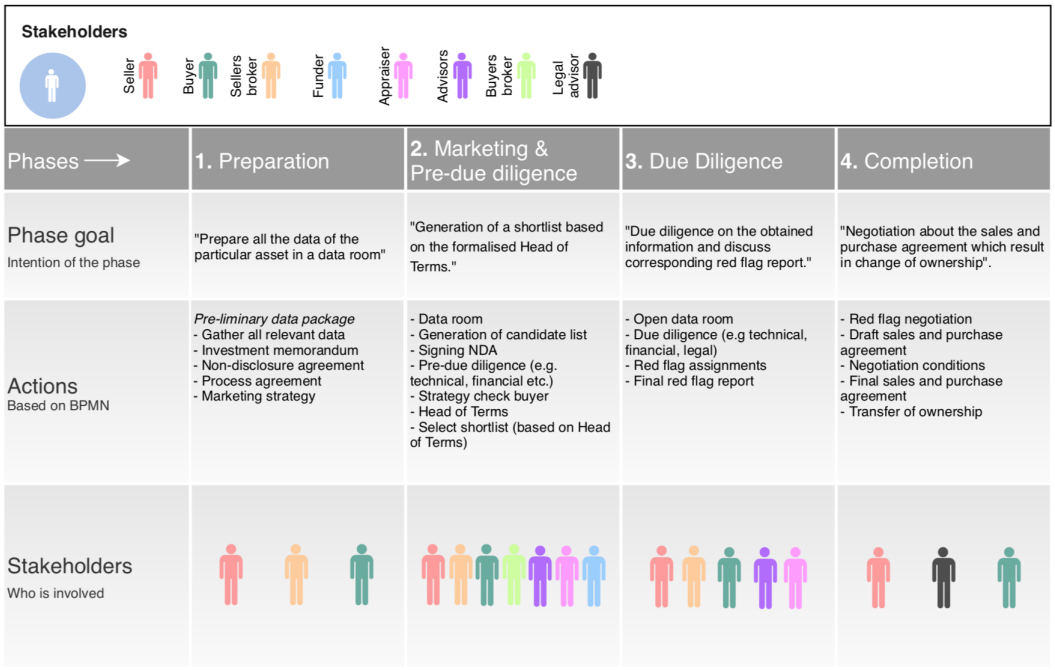

Figure 17: Simplified BPMN model

5.2 Pain points

Literature defines various inefficiencies and challenges in real estate transactions. To obtain in-dept knowledge regarding these inefficiencies and challenges, pain points are identified based on semi-structured interviews (Round 1, Chapter 4).

From the interviews it can be concluded that all interviewees are mainly experiencing pains regarding *data quality* and *data structure*. The mentioned pain points are essential to create a clear overview of the property (properly define the product you are selling or buying). A lacking overview could result in an initial or final bid that could not be realized. Furthermore, information could be interpreted differently what unnecessarily lead to delays during the process.

> (*Appendix C – Interviewee D*) "... very difficult to properly define what you are really selling."

In this section the results of the semi-structured interviews (Round 1) are described in detail.

5.2.1 Data quality

The term data quality implies the reliability – inconsistent or unreliable data – of office building related data. In many cases the data is outdated, e.g. inner walls are removed and elevators are replaced by stairs. In the beginning of the process – during the draft of an investment memorandum, it is assumed that the obtained data (Task 1) is correct. Since, this data forms the input of the transaction process and subsequent assumptions. However, all interviewees indicate that obtained data is often outdated what result in problems that could have consequences during the transaction process of an office building.

> (*Appendix C – Interviewee A*) "Data regarding the property is in many cases outdated... The reliability is essential for the valuation of the property."

> (*Appendix C – Interviewee B*) "... quality of data is essential. This will also be reflected later in the due diligence (DD) process."

(*Appendix C – Interviewee C*) "Obtained information is often unstructured, incomplete or incorrect."

(*Appendix C – Interviewee C*) "... otherwise the quality of input data".

The mentioned pain point of lacking data quality is schematically visualized in Figure 18.

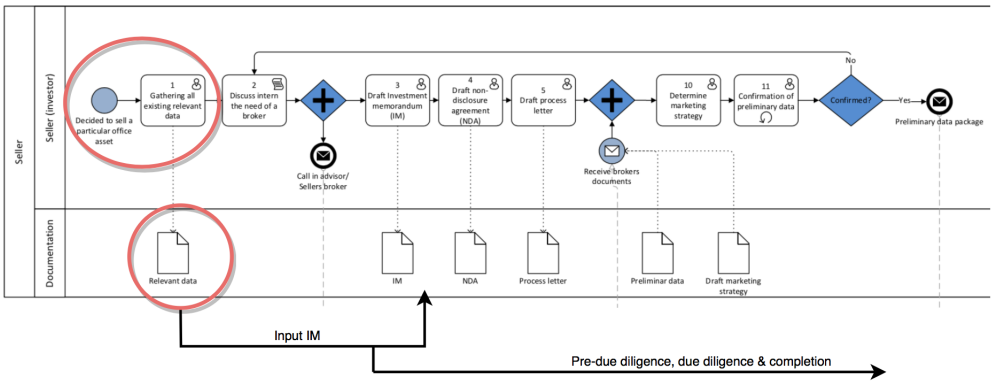

Figure 18: Pre-liminary data gathering process (preparation phase)

The data gathered by the seller (Task 1) forms the input for following steps (e.g. drafting an IM, *Task 3*) in the process. In addition data obtained from the seller forms the input for a data room. Both, the IM and, in a later stage, the data room are shared with potential buyers. Based on this data a buyer will execute checks (pre-DD and due diligence) to form a Head of Terms (initial bid) and final bid. If data quality is already lacking in Task 1, tasks hereafter are slowed down, which indirectly results in higher (transaction) costs. Therefore, data should be updated and validated during the life cycle of a property.

In addition to *data quality* the next pain point is mentioned by all interviewees: '*data structure*'.

(*Appendix C – Interviewee A*) "You should consider: what is the quality of the obtained data and above all is the data that I use complete".

The last part of the quotation – "...is the data that I use complete" – initiates the next pain point.

5.2.2 Data structure

In addition to data quality all interviewees mentioned the structure of databases – missing or incomplete data – as major pain point. Although rental contracts (lists) are stored in property management tools – such as Yardi – invoices, allonges, revisions are stored in other systems or by other parties. There are various data rooms and parties with information regarding the specific property – Yardi tool, property manager, third parties (maintenance companies). However, all information is needed to start a transaction process. The collection of all available *decentralized stored* information results in the pain point: '*data structure*'.

(*Appendix C – Interviewee C*) "Stored data is unstructured, incomplete or even incorrect."

(*Appendix C – Interviewee D*) "Various parties know something about that specific property, but to ensure that all the information comes together at the right time is almost impossible."

All interviewees mentioned that many organizations work decentralized which results in a situation that files are locally stored – separate Excel- or PDF files, folders on separate computers. Due to the decentralization of working by organizations, files are hosted on various computers owned by property managers and third parties. On the one hand, investors would benefit if they are

not wasting unnecessarily time searching for data (information). For investors it is essential to have data well structured in order to have the best possible overview of their real estate. On the other hand, investors do not want any surprises during the due diligence period. For example, a property manager makes appointments with a tenant regarding rental agreements, but leaves this information in his email-inbox instead of entering it in a customer relationship management (CRM) or property management system. When obtaining data for an IM, this tenant specific information stays remain what could cause complications during the transaction process

Besides the two major pain points interviewees mentioned that not only during the transaction process of an office building multiple stakeholder are involved, but during the management period (also referred to as operation phase or life cycle management) of a property as well.

> (*Appendix C – Interviewee A*) "... multiple parties are involved trough the life cylce of a property and should work with the same data (version). However, it turn out in practice that parties are using different documents."

The circulation of various documents (e.g. Excel files, PDF's, etc.) and versions decrease the reliability of process. To come full circle, the circulation of multiple documents results in outdated and thus unreliable data which results result in lack of quality.

5.2.3 Pain point definition

The outlined pain points in Section 5.2.1 and 5.2.2, as a result of the interviews, are seen by the interviewees as an risk identification and time losses.

> (*Appendix C – Interviewee A*) "The problems result in an inefficient process and increasing associated costs, these effects are coherent."

However, interviewee D (Appendix C) mentioned: "On the other hand, risk (pain points) could be prized, that is what every investor does. A investor makes an assessment of the risk and expresses it in money." Investors are continuous analyzing their risks and resulting return. Thus, associated transaction risks and delays during the process result in leveling returns what is reflected in a (lower) final bid.

5.2.4 Allocation pain points

According to the interviewees multiple pain points occur during the transaction process. In this section, the pain points mentioned by the interviewees are allocated to the four transaction phases (Section 5.1). The interviews indicate that, although the pain points are visible during the due diligence and completion phases – schematically visualized in Figure 19 – they are formed during earlier phases or even before the transaction process starts. This will be explained in this section.

The mentioned pain points (Section 5.2.1 and 5.2.2) are clearly visible during the completion and due diligence phases. Therefore, the approach of this section is the other way around, starting with 'visible' pain points during the *completion phase*.

> (*Appendix C – Interviewee B*) "SPA is a difficult process at the end. The purchase agreement often results in a lot of discussions between the parties."

> (*Appendix C – Interviewee D*) "The completion phase is known for its long negotiations about guarantees."

The visible effects of the mentioned pain points can be assigned to the 'range' – lack of transparency – between the available information and interpretation of information by the seller and potential buyer. One of the consequences of disagreements about obtained information is related to conditions/guarantees in the sales and purchase agreement (SPA). Hence, the negotiation regarding these conditions are unnecessary long. Reducing the 'information gap' will indirectly result

in reducing disagreements, as well as the amount of conditions/guarantees during the completion phase.

Additionally, pain points raise during the *due diligence* process (DD process). Due diligence is the process of checking all the relevant available data.

> (*Appendix C – Interviewee B*) "A due diligence process could be inefficient due to the lack of available information."

> (*Appendix C – Interviewee D*) "... the buyer finds out during the due diligence process that the initial price is grounded on unreliable data and the initial price is not a faithful representation."

External advisors need the data from the data room – provided by the seller – to execute (physically) checks, which forms the input for so called red flag assessments and reports. If it turns out that data is incomplete, advisors or buyers need to contact the seller to obtain the missing documents. If documents in the data room are missing or incomplete the DD process could be delayed.

"Pain points are relatively small at the beginning (preparation phase), but once in DD the problem can be big" (*Appendix C – Interviewee D*). The pain points mainly occur during DD and completion, which is schematically visualized in Figure 19.

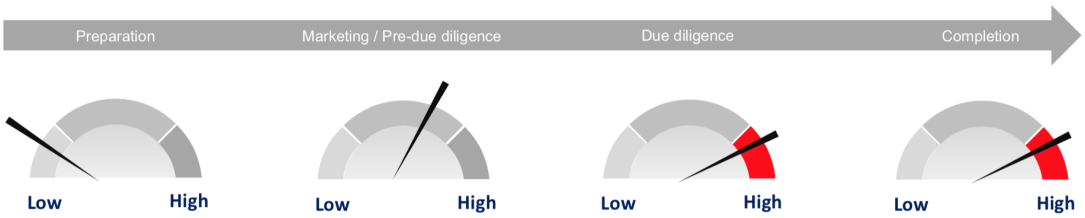

Figure 19: Pain points priority allocated to the transaction process

It can be assumed that pain points are partially formed during the *preparation phase* – where data is gathered. During the other phases in the process data is verified whereby problems emerging.

> (*Appendix C – Interviewee B*) "Data gathered in the preparation phase forms the input for an IM. Based on this IM and general external research (pre-DD) an initial bid is proposed. Information incompleteness could result in delays during pre-DD, but when in-dept research is executed (DD) incompleteness could lead to bigger problems, refrain from the deal or liability issues."

During the pre-DD phase more understanding about the property and its corresponding value is obtained. External experts can be involved to make assumptions. This is the first moment that potential issues in data can be discovered. However, there is a significant greater chance of discovering incomplete or outdated data when in-dept research is carried out during DD.

The analyzed data in the pre-DD is composed in the *preparation phase*. What matters is the completeness and reliability of the date during this phase, since this data forms the input to succeed the follow-up process (marketing/pre-DD, DD and completion) .

> (*Appendix C – Interviewee C*) "An IM should be fully based on the truth."

> (*Appendix C – Interviewee B*) "... at the beginning of the process you draft an IM – your sales brochure. The information in your IM is based on the available information that you received from the seller."

The preparation phase consists of elements prior to the actual transaction process. All available information will be included in a data room, which is the input for the transaction process. Information required for transacting real estate is obtained from multiple parties (e.g. property manager). Property managers are responsible for managing the property trough its life cycle, also referred to as operational real estate management.

> (*Appendix C – Interviewee B*) "... did not receive all the information from the property manager. Information provision is the most important delay factor."

> (*Appendix C – Interviewee D*) "... property managers should have a property management tool that contains all data from tenants and the building (up-to-date tenant data and including BIM data at the moment the building is built)"

It could be concluded that the mentioned pain points (Section 5.2.1 and 5.2.2) are related to data during the first task (Task 1) of the preparation phase and even before. The data should be validated before the transaction process even starts or after gathering all available information by the seller. The interviewees indicate that data originated from an internal- or external property manager. As long as the office building is proper functioning – returns are positive and tenants wil be satisfied – neither a property manager or owner (investor) mention data issues. Data issues appear only when a potential buyer will do in-dept checks during a transaction. This proves the important place of the property manager before and in a transaction process of an office building. Therefore, an extra interview is conducted in the next section regarding property management of an office building.

5.2.5 Property management

According to all interviews and the allocation of pain points in the transaction process, lacking information can be linked to property management (operational real estate management). Due to this finding, tasks and function of the property manager are explained on the basis of an extra semi-structured interview and literature of Driel van (2010).

Property management includes all operational real estate management tasks in relation to an object (Driel van, 2010). For explaining property management reference should be made to the real estate management pyramid (Figure 20). Real estate management is divided into three management domains: portfolio, asset and property. Portfolio management focuses on managing multiple offices on a strategic level. Due to the focus of this research portfolio management shall be excluded. Within the real estate management pyramid the focus in this chapter will relay on transacting one office building. Asset management is already outlined in Chapter 2. Due to the findings of the semi-structured interviews property management, also referred to as operational management, is analyzed in more detail.

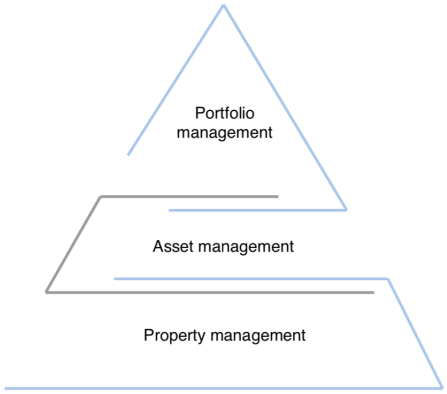

Figure 20: Real estate management pyramid. Source: (Driel van, 2010) edited by author.

Property management can be divided into technical, commercial and administrative activities. Tasks of a property manager are outlined in Appendix E according to Driel van (2010). It turns out in practice that investors often outsource property management activities to external organizations based on region or specialization (Appendix C - Interviewee C).

Property managers are responsible for managing and administrating the property during its life cycle. The interviewed property manager stated that the difficulty mainly lies in record-keeping of adjustments to 'original' documents (Appendix C - Interviewee E). Record-keeping during the operational phase could be divided into four groups of adjustments, also referred to as revisions:

- Capital expenditure (CAPEX) – planned maintenance (10 years).
- Spontaneous – a leakage of a pomp.
- Deliveries and services (service costs) – revisions within lease contracts (e.g emergency lights).
- Tenant related – proposed changes of the tenant what a property manager should approve.

Currently, information related to above mentioned revision groups are stored decentralized – by multiple parties. Interviewee D indicates that if specific detailed information is requested, information needs to be requested by third parties. Hence, interviewee D questions:

> (*Appendix C – Interviewee D*) "The problem that we are facing is do we need all the transparency. For example, it would be interesting to store all certificates in a database. However, for that one time the certificate is needed it could be requested by a contractor as well"

Referring to transacting real estate, the involvement of a property manager in a transaction process is not within the scope of his tasks (Appendix E). Although interviewee D stated that the property manager is often involved respectively late in the process, in the beginning of the process the property manager is asked to send all available information to the owner. However, the role of a property manager mainly relays on giving additional information during the DD.

5.3 Summary

Based on the empirical findings regarding the current transaction process of an office building, the third sub-question can be answered: '*What problems can be identified during the current transaction process of an office building?*'.

To get a better understanding of the process, the stages identified in Section 2.2 are visualized based on business process modeling (BPMN). BPMN is the leading standard in the frame of business processes and workflow modeling languages. In this model the following stages are distinct and visualized: preparation, marketing and pre-due diligence, due diligence and completion (Appendix D).

Earlier it is identified that CRE transactions are known for their lack of transparency, inefficiency and complexity. To support this, interviews were conducted to identify and map pain points to specific phases and tasks in the transaction process. Grounded on the proposed BPMN model of the current transaction process, interviewees were asked: '*What major pain points encounter during this process?*'. The mentioned pain points are probably most interesting to address, because a solution to this matter would result in a solution with major benefits. First, all interviewees unanimous mentioned that pain points can be defined as time delays in the process what result in a raise of (transaction) costs. Secondly, they mentioned data *quality* and data *structure* as major pain points. A tool to overcome these pain points – which can be attached to specific tasks or phases – should result in an enhancement of the current transaction process. Both pain points occur mainly during due diligence and completion, but are grounded during preparation or even before this phase.

Garbage in, garbage out.

In addition, all interviews mentioned data management during the life cycle of a property (life cycle management). To obtain a more in-depth knowledge about the problems faced, a property manager was asked to reflect on the pain points in the transaction process. It can be concluded that a property manager is responsible for technical, commercial and administrative activities during the life cycle of a property. However, property managers work in a decentralized fashion which causes various pain points and challenges. Furthermore, property managers mainly focus on proper functioning of the office building. As long as the office building is properly functioning, during the property management period of an asset, pain points would not occur. Pain points do occur when the seller decide to sell the property and the potential buyers are fulfilling checks (pre-DD and DD). Hence, the property managers does not have a direct incentive to submit up-to-date information.

If we are to improve the transaction process, the proposed solution should resolve identified pain points and, as a result, streamline the transaction process of an office building. Based on the mentioned pain points the next chapter will propose a solution which improves the current way of transacting CRE.

Chapter 6

Blockchain model

In the previous chapters a theoretical framework is drafted and the empirical findings are elaborated. As described in Chapter 4, this chapter proposes a blockchain database to improve the current transaction process. This chapter aims at answering the fourth research question, which reads as follows: '*What blockchain technology features could be used to improve the current transaction process of an office building?*'. Before proposing a solution, the focus within the process is described (Section 6.1). From this point Section 6.2 proposes a foundation for a solution without blockchain technology. The proposed solution forms the principle for the analysis how blockchain technology should be implemented to enhance the proposed solution and overcome the pain points (Section 6.3). In Section 6.4 the proposed databases are compared. Finally, this chapter is wrapped up in Section 6.5 with an answer to the fourth research question.

6.1 Current process

Literature divides the transaction process of an office building into four phases: preparation, marketing and pre-due diligence, due diligence and completion. Due to multiple due diligence phases and negotiation rounds the reliability and efficiency of the process are put in doubt. In addition interviewees (Chapter 5) indicate data structure and data quality as major pain points. Although these pain points are visible during due diligence and completion, they are grounded in the preparation phase or even before – during operational management of the property.

Section 5.2 concludes – in order to efficiently run the process – that the transaction process depends on data structure and data quality. Currently, one of the first tasks within the transaction process is gathering all available and relevant data (Figure 21 on page 48). All interviewees mention that this is done by external- or internal property managers. However, due to the decentralized way of working in organizations, data is stored on various locations. Therefore, property managers are not able to provide all the data and the correct version of the data. So, during the preparation phase incomplete data with lacking quality is provided by third parties which could have consequences for the transaction process, and particularly result in a time consuming process.

In Figure 21 it is visualized that data gathered in Task 1 forms the input for the next phases in the process. Currently, the data room (Task 12) is prepared after Task 1 till 11. However, this data room should be the starting point of the process. Based on the data room the seller is able to properly define what he/she is selling – assuming that the data is correct. This could be described as a preparation DD from a sellers point of view. *Properly defining the specific asset*, contributes to strategy and process determination by the seller. Besides data structure, data quality is defined as major pain point. Improvement of data structure will not automatically result in an improvement of data quality. According to all interviewees solving both pain points is essential to improve the transaction process.

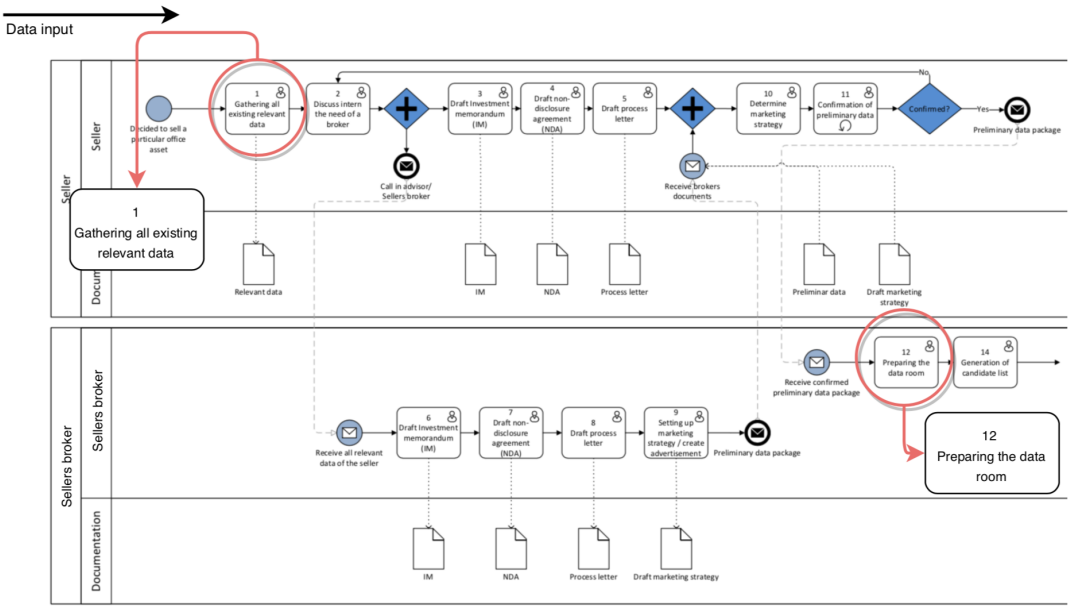

Figure 21: Preparation phase BPMN

6.2 Centralized database

Both literature and interviewees indicate the need for more structure and quality of data within the transaction process. One of the interviewees even makes the comparison between a share of a (small) company and a real estate portfolio, in the sense of transparency. Involved parties should know what they are selling or buying. Nobody wants to have '(bad) surprises' when purchasing an office building. Therefore, checking and validating the characteristics (e.g. technical, commercial, legal and financial) of a property is critical to succeed. Insight in property related elements obtains adequate information regarding its economic value, but also avoid running costs.

'Nobody wants to buy sour milk' – Tim Cook

As all interviewees indicated a well-structured data room, document transparency and quality will certainly save time and hence costs during the transaction process of an office building. It can be assumed that this is the core of a successful deal.

In this section a foundation for a solution, called solution principle, is proposed. Based on the solution principle the added value of implementing blockchain technology is analyzed. In Chapter 7 the proposed model is validated.

6.2.1 Centralized database features

Currently, one of the first tasks within the transaction process is gathering all available property related data (e.g. contract, agreements, inspections etc.). Due to the decentralized way of working, documents (e.g. rent indexations or technical inspections) are stored on different servers by multiple parties. Finding a document half way the transaction process or even after the actual transaction could have big consequences. Furthermore, locally stored documents are stored in various formats (e.g. Excel, PDF and even ring binders). Therefore, all respondents mentioned *data structure* as major pain point.

As mentioned before, it is essential to properly define what you are actually selling or purchasing. If a database is implemented at the beginning of the process or during the life cycle of a property it can be ensured that documents are well structured according to the standards of the database.

That is why a centralized database is proposed where all building related information is stored. From this centralized database the transaction process can be started, as is visualized in Figure 22. All property related files can be stored on one physical server. All involved stakeholders are connected to this centralized database.

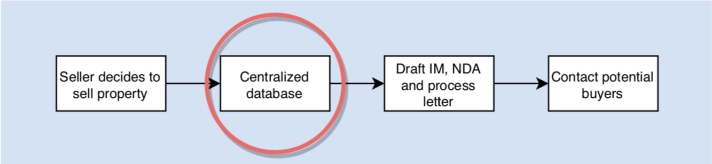

Figure 22: Proposed centralized database

A centralized database contributes to the structuring of all available data. Structuring of data according to database standards will support parties in properly defining what they are selling or buying. The theoretical framework elaborates an information checklist for properly defining office buildings for a transaction process (Section 2.2.3). The information checklist is divided into nine elements: marketing, legal title & searches, management information, design & construction, utilities, planning/statutory/infrastructure, physical conditions, rate/outgoing and financial. The 'general' checklist is reduced into four indexes in the proposed centralized database: technical-, commercial-, financial- and legal index (Figure 23). First, *Technical index* includes data regarding the physical elements and conditions of the building. Secondly, the *Commercial index* includes data regarding tenants (e.g lease contracts, allonges etc.). Thirdly, *Financial index* includes data regarding financial documents (e.g. loan information and debt payments). Finally, data related to legal documents (e.g. title documents) are included in the *legal index*. These indexes form the input for a general building overview, marketing material and other property related reports.

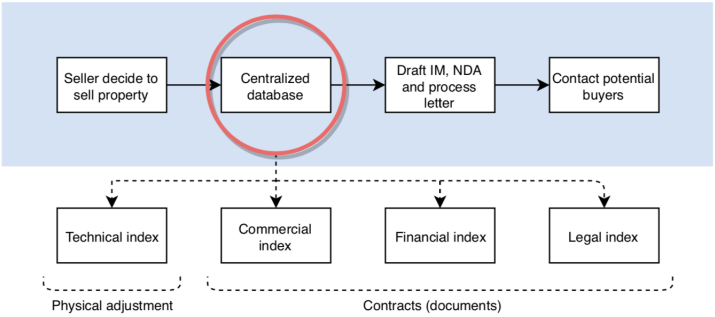

Figure 23: Input centralized database

Instead of gathering data via multiple sources (decentralized) in the old situation, a seller (owner) will obtain data from the centralized database in the new situation. The decentralized way of working – which results in locally stored files – will change by implementing a centralized database. However, the proposed database should be provided with input data. Although implementing a centralized database with technical-, commercial-, financial- and legal data increases the way of structuring data, it does not guarantee *data quality* – the second mentioned major pain point. To guarantee data quality, documents should be validated by two or more involved parties. All required documents for technical-, commercial-, financial- and legal index are uploaded in the database when buying a property. In case of an revision to documents, validation from two or more parties is required. By validating a revision, it can be assumed that documents in the centralized database are correct (up-to-date). For example, within the commercial index information of tenants is stored (e.g. rent price or ownership title). If the rent price is modified, both tenant and owner needs to validate the modification, and save the modified contract in the centralized

database. By validating the rent price modification, the adjusted documents are saved in the centralized database and represent a new version of the contract.

Where commercial, legal and financial adjustments mainly rely on contract related changes, technical adjustments are often tangible (physical, Figure 23). For example, a company like LegalThings[7] offers standardized contracts for transforming the drafting process of real estate agreements. So, the challenge relies mainly in monitoring these revisions. The next section propose a solution to monitor physical and contractual elements in the proposed centralized database.

Physical element

Within the technical index, physical adjustments or maintenance occur. To outline a *physical elements* it is important to understand what kind of information needs to be stored in the database. Copper8 and Alba Concepts (2017) defines four aggregation levels of a building: systems, elements, products and materials. The aggregation levels are outlined in Figure 24.

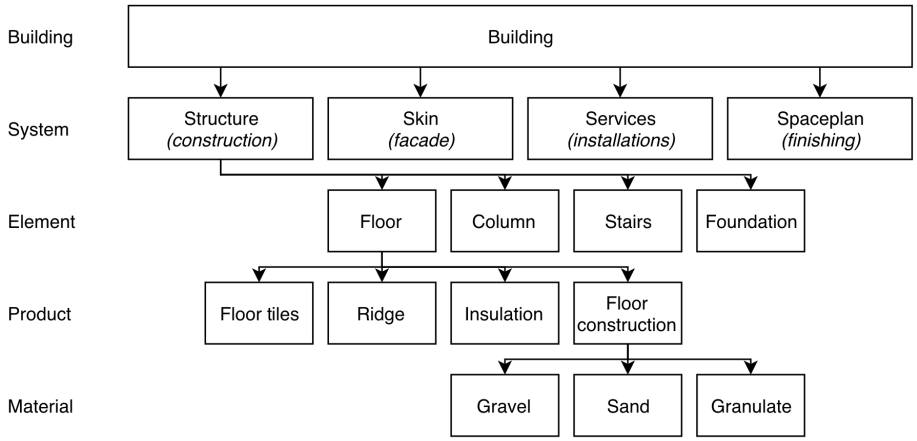

Figure 24: Building aggregation level matrix. Source: (Copper8 and Alba Concepts, 2017, p. 14) edited by author.

Based on this matrix a physical element overview of a building can be created – including all (*physical*) building related information. According to the information checklist for transacting real estate, only general information regarding a building is important (Section 2.2.3). Hence, the focus of physical elements will rely on system level (structure, skin, services and spaceplan) and corresponding elements as proposed by Copper8 and Alba Concepts (2017). For example, the centralized database is linked to an existing building. After buying the property, operational management of the owner starts. First, all documents obtained and checked (DD) from the purchasing process are stored in the centralized database. It is assumed that all required documents are obtained when purchasing the property. For managing the property it is important that during the life cycle of the property adjustments to the original data are kept in the database. Based on this up-to-date database it is possible to properly define the property and guarantee the quality of the documents.

During the operation phase, the property manager is responsible for technical- and commercial administration (Section 5.2.5). Although, commercial administration rely on contractual adjustments, technical administration is tangible and should be validated by physical checks, invoices, reports and warranties. Validation of these documents – checking the information by property managers and third parties – result in up-to-date data during the life cycle of the property. The process of validating a physical element is visualized in Figure 25.

[7] https://goo.gl/aLgBCp

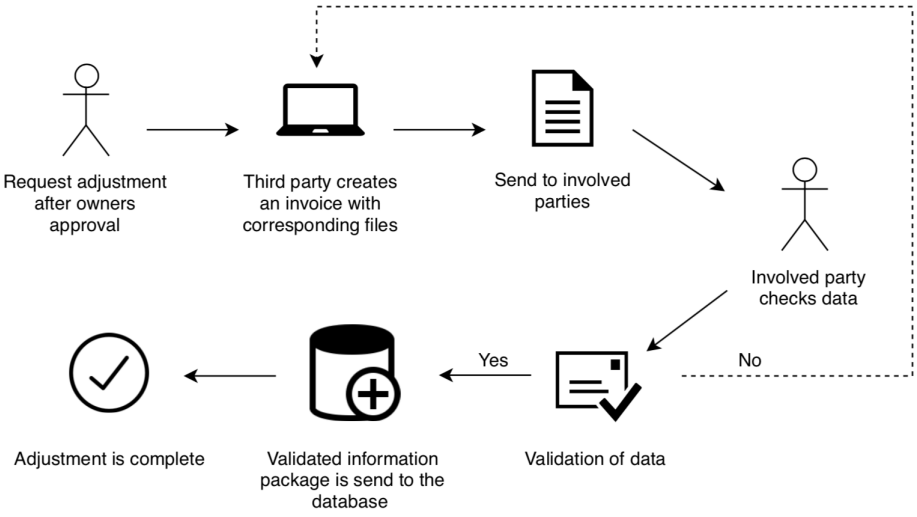

Figure 25: General example validation adjustment.

First, for example, a property manager request a third party (carpenter) to do an physical adjustment (after the property manager gets approval by the owner of the building). After changing a wall the carpenter creates an invoice and report with corresponding files regarding the adjustment. This data package is summarized a framework – class diagram visualized in Figure 26 – and send to the involved parties (e.g. property manager or owner). Involved parties check if the adjustment is correct, and thereafter validate the data by a digital signature, which results in a validated information package. If the information is incorrect an message will be send to the involved third party. After validation, the information is add to the centralized database and the adjustment is completed. The validated adjustment consists of multiple data elements, which is outlined in Figure 26 on the basis of a framework. In this way, data in the centralized database is validated to guarantee the quality.

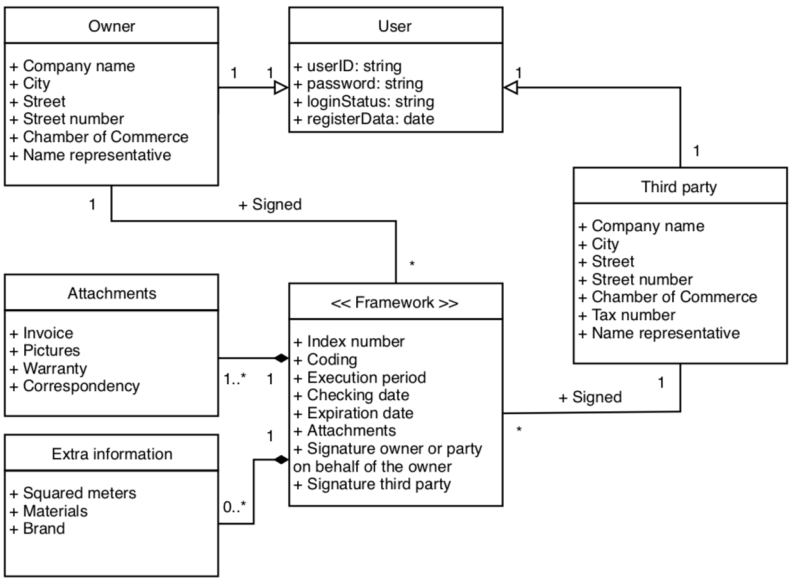

Figure 26: Class diagram physical element.

By including a framework (Figure 26), most important aspects of the validated information could be presented. Each physical information element (e.g. a physical adjustment) is coded according to the index code and linked data method (explained in more detail later on). Next, information about the period of the adjustment is requested. Then, content data regarding the adjustment should be obtained (e.g pictures, invoices, used materials and adjusted m^2). Finally, all the data is validated by all parties, which guarantees the quality of the adjustment.

The process of administrating an adjustment from a third party perspective can be expressed in different phases, which is visualized in Figure 27. First, an (index) adjustment request is received with corresponding private key (authorization code). The third party is able to log in into the system and 'read' the related index information. After reading the information of the current situation the physical adjustment is executed. Based on the adjustment an overview is created in the framework of Figure 26 and send to the involved property manager. The system should automatically fill in the related index number and execution date. Hereafter, the third party can log out of the system.

To allocate an adjustment, the Element Method[8] (EM) can be used, also called NL/SfB coding. In the construction sector NL/SfB is a classification method which indicates the building element in which a building component or material is located. This coding method is used during the design, realization and management of construction projects. NL/SfB organizes objects and layers in CAD-systems, which allow categorization of e.g. elements. However, categorization based on the NL/SfB is outdated and often criticized due to lacking ICT-integration. Additionally, linking objects to elements by EM is often difficult and not clear to the involved parties. For example when a third party is executing an adjustment on a door, they often not exactly know which 'code group' belongs to this adjustment. Therefore in this solution a more accurate coding element method is used: 'Linked Data' (LD)[9] – a method to publish semantic data (Corry et al., 2013). LD is a taxonomy for entities based on object properties as well as the NL/SfB coding method. However, LD rely on the principle of web standards (e.g. HTTP-URI's & RDF) and creates links between different sources (Bizer et al., 2009), which relies on the following principles:

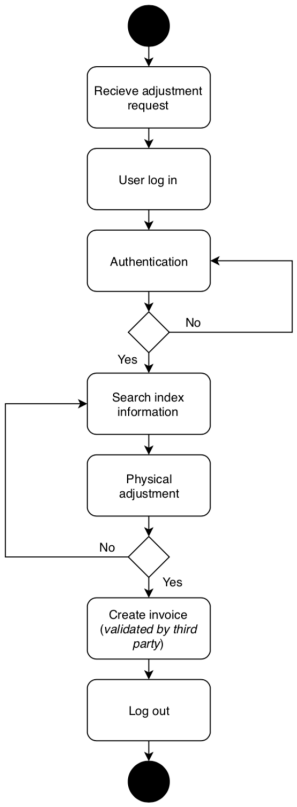

Figure 27: Workflow from a third party perspective.

- *Uniform Resource Identifier (URI).* Is a string of characters to identify building objects. An example of an URI can be very concrete like a room or wall, but can also represent a more abstract relation between elements or groups.
- *Hypertext Transfer Protocol (HTTP) of URI's.* Is an unique hyperlink which can be found by everyone.
- *Resource Description Framework (RDF) metadata.* It provides useful standardized information framework.
- *Links to other URI's.* The connection of hyperlinks to other concepts in the data sets.

[8] https://goo.gl/7L5oLW
[9] https://goo.gl/iYoGNW

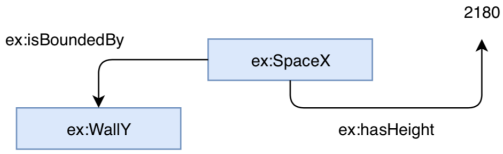

Figure 28: Linked data example. Source: (Kalpoe, 2016, p. 37).

Figure 28 illustrates a schematically example of the applicability of linked data. Assuming that the subject (a real world entity), such as a space or a whole floor in a building, is uniquely identified as `http://example.com/ABNAMRO-GM/D-Tower/Floor16/SpaceX` which overall height (`http://example.com/ABNAMRO-GM/D-Tower/Floor16/SpaceX/Height`) is represented by '2180', referring to a height of 2.18 meters. Furthermore, the space has an element (`http://example.com/ABNAMRO-GM/D-Tower/Floor16/SpaceX/BoundedBy`) that has the unique URI `http://example.com/ABNAMRO-GM/D-Tower/Floor16/SpaceX/WallY` (Kalpoe, 2016, p. 37). Using the LD method result in a traceable code for elements in a validated information document. Figure 29 visualizes the implementation of two technical elements.

#	Element - Lights	Data
1	Index number	1.12
2	Linked data code	example.com/Floor3/Space4/Light
3	Execution period	10-08-'18
4	Last checking data	29-08-'18
5	Expiration data	n/a
6	Attachment (e.g. invoice, warranty, picture etc.)	Invoice, warranty & pictures
7	Replaced m²	n/a
8	Material	n/a
9	Brand	Philips
10	Signature owner (or property manager on behalf of the owner	Property manager ✔
11	Signature third party	Electrician Amsterdam ✔

#	Element - Boiler	Data
1	Index number	1.9
2	Linked data code	example.com/Floor3/Space1/Boiler
3	Execution period	05-12-'18
4	Last checking data	20-12-'18
5	Expiration data	05-12-'18
6	Attachment (e.g. invoice, warranty, picture etc.)	Invoice & warranty
7	Replaced m²	n/a
8	Material	n/a
9	Brand	Miele
10	Signature owner (or property manager on behalf of the owner	Property manager ✔
11	Signature third party	Allround Building Service ✔

Figure 29: Example physical element framework: lights (l) and boiler inspection (r).

The added value of using the proposed 'principle solution' (technical adjustment) is in the first place creating structure in all building related data, which is controlled by one party. After purchasing a property, documents from the previous due diligence will be saved in the system. During the life cycle of the property a logbook will be kept to assemble all changes to the original documents. Currently, databases are held decentralized (digitally or on paper). In this way, overview is missing and quality is lacking. By digitizing and validating adjustments in a centralized database, structure will be created and quality can be guaranteed by its validated framework.

Contractual element

In contrast to tangible technical indexes (physical elements) most of the commercial-, financial- and legal- (CFL) adjustments mainly rely on contract changes. CFL indexes are outlined in Appendix F. To outline CFL adjustments it is important to understand what kind of adjustments may occur. For financial- and legal indexes detailed information & standards are difficult to obtain. However, for the commercial index 'De vereniging Raad voor Onroerende Zaken (ROZ)' defines a standard rental agreement model, called ROZ-model (Appendix G). A contractual element is outlined on the base of a ROZ-model (Figure 30).

First, for example, the owner requests an new contract or adjustment to the current contract (ROZ-Model). After, changing the clause of the contract, the contract is sent to the tenant – with (mail) correspondence – and needs to be validated by both parties. Finally, a new version of the contract is stored in the centralized database and a corresponding overview document is submitted (Figure 31).

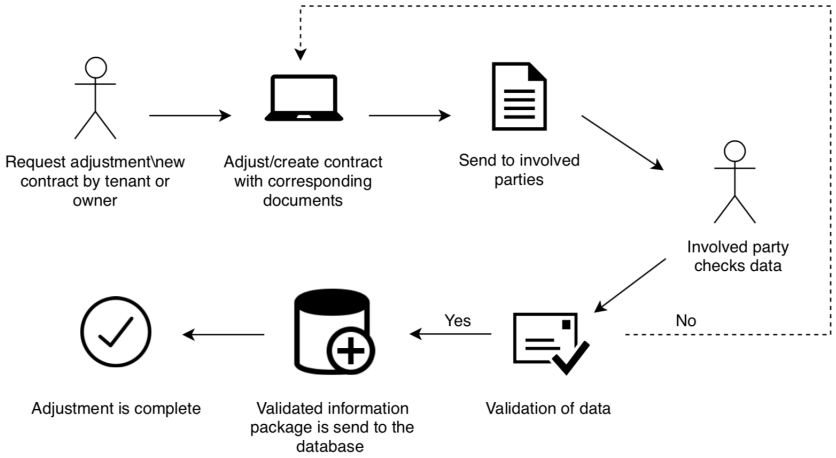

Figure 30: Contract adjustment.

Where physical elements will be coded by LD, contracts are subdivided into articles, sections, subsections and other enumerated clauses. In the ROZ-model various clauses are grouped in chapters (e.g. 3.1, 4.3, 5.6 etc.). It enables cross-references whereby readers can efficiently find specific information. Clauses are used to allocate adjustments in the proposed centralized database. Figure 31 visualizes the proposed contractual framework. In the proposed framework a contractual element is allocated to an index. However, standardization of contracts enables clauses reference. As outlined, each contract should consist of attachments such as the original contract and e.g. mail correspondence. To validate all requested information both parties have to (digitally) sign and check the adjustments according to the contractual framework (Figure 32 on page 55).

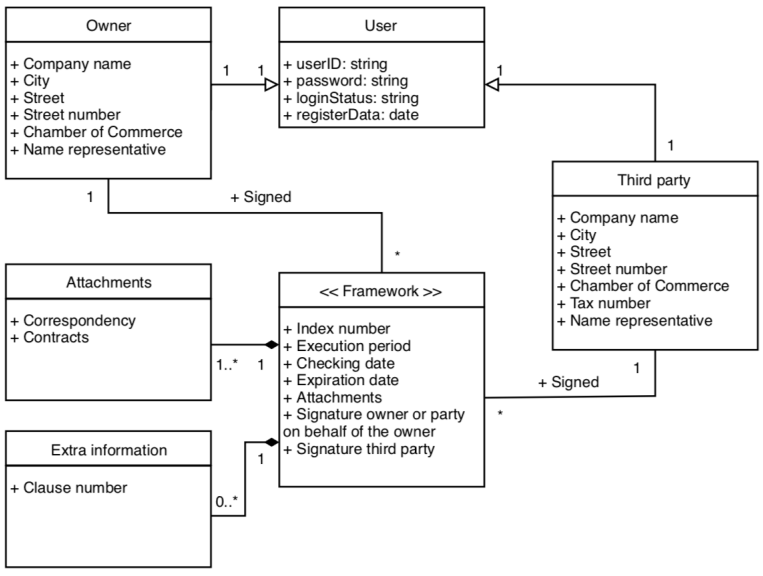

Figure 31: Class diagram contractual element.

The added value of using the proposed framework in a centralized database is in the first place creating structure in all physical and contractual related data. After purchasing a property all validated data in the DD will be stored in the system. With the proposed database it can be recorded what changes are made to the original documents during the life cycle of a property. By digitizing and validating adjustments in a centralized database with corresponding validated data, structure will be created and quality can be guaranteed.

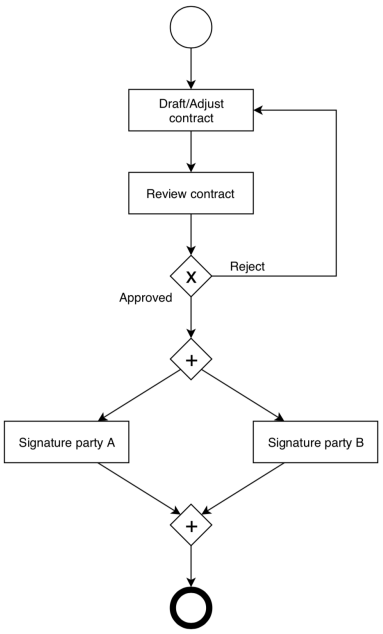

Figure 32: Contractual adjustment in a centralized database.

Authorization key

The transaction process of an office building is described by the literature and interviewees as a process with multiple parties. The involved parties are described in Section 2.2.1. In order to keep an overview the centralized database is only accessible with a private authorization code – log in name and password. Documents will have 'read' and 'write' authorization levels. Pre-defining authorization levels – to precisely control privileges of individual users – is an important factor for sharing information between parties. In a centralized database all data is stored on a server and managed by a single node (e.g. owner of the building). This single node is authorized to assign permission rules to both parties and files within the database.

The centralized database can be used during both the operation- and transaction process – *the life cycle of a property.* Involved stakeholders will have their own private key (authorization key) with specific permissions. During the operation phase of a property, the property manager and owner – in collaboration with third parties – are responsible for the validation of adjustments to the original data, which creates an audit trail of information. In the transaction process potential buyers will receive a private key and are able to 'read' specific data elements within the database. In this way, a seller is able to determine a strategy on sending information in the pre-DD and DD phase of the transaction process: 'What kind of information should I give to a potential buyer during the pre-DD phase?'.

Only the companies that have access to the data elements inside the database can read (view) or write (validate) data. Besides authorization levels, a private key enables track and trace parties in the system – who is responsible and liable for which specific file. So, the access to the database will be structured according to 'who has what rights'.

6.2.2 Challenges centralized database

In a centralized database all data is stored on one server and managed by a single node (owner or third party), only users being distributed in the network (Figure 33). This requires a sufficient level of trust in the owner that the data is properly maintained and accessible to involved parties. This not only concerns trust that the administrator carefully handles within its permission to refuse access and adjust specific data. But, also database management related tasks. Because, all 'power' within the database is located by one single node. This node can decide who has what rights – 'read' and 'write' permission. This situation can sometimes lead to unpleasant situations, for example when a potential buyer request data regarding valuation reports. The owner is able to give only documents that show the property in its best light. A seller (owner of the database) has another incentive regarding the transaction prices compared to a potential buyer. The sellers incentive is to get the highest price for the property. Therefore, more critically reports can be

omitted by the owner of the property and database, which decreases the liability of the proposed system.

Additionally, a physical server is sensitive for loses of data and hacks. The contents of a database are stored in a particular computer system, and anybody with sufficient access to that system can destroy or corrupt the data within it. Furthermore, the enormous amount of data that is stored on one server (huge storage capacity, which is technically possible) can result in a storage problem and reduces the speed of the server.

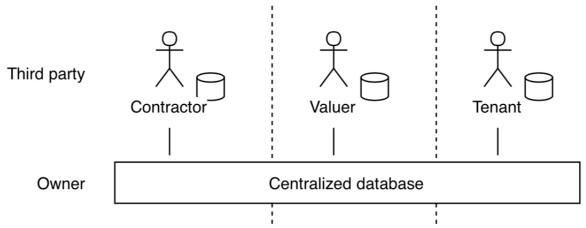

Figure 33: Current way of working in centralized database.

The mentioned challenges of a centralized database can possibly be overcome by the implementation of blockchain technology as new data management technology. The next section will analyze the consideration and implementation of blockchain technology, to overcome both major pain points and challenges of the proposed solution.

6.2.3 Conclusion centralized database implementation

Both literature and empirical findings indicate the need to properly define an asset. Currently, pain points during the transaction process can be allocated to 'data structure' and 'data quality'. Involved parties *are not* able to define what property they are actually selling or buying. This results in delays or early rejection for potential buyers during the transaction process. To solve the mentioned pain points this section proposes a centralized database consisting of technical-, commercial-, financial- and legal indexes. The indexes can be subdivided in physical and contractual elements, which are outlined in more detail. After buying a property, the owner imports all (validated) property related documents from the previous transaction process in the centralized database. During the life cycle of the property adjustments can be logged by submitting information (class diagram) per adjustment as the framework prescribes (Figure 26 and 31). The documents are coded based on LD (physical adjustments) and clauses (contractual adjustments). Besides, coding the validated adjustments, a time stamp and signature by the involved parties ensures the quality of the document. Furthermore, authorization rules – defines who has access to specific information – make it possible to 'personally' sign documents and trace adjustments. The proposed solution enhances data structure and data quality. Although, the proposed solution is a helpful tool to overcome the mentioned pain points, some challenges arise as well.

- One party (owner of the building) has all permissions within the centralized database. This requires a sufficient level of trust. Currently, the due diligence process in a transaction process indicates that there is a lack in trust among involved parties.
- Storing all property related data requires a server with a huge storage capacity. However, having all physical documents is not always necessary.
- One physical server is sensitive for loses of data and hacks.

Based on the proposed solution it can be determined which aspects can be addressed with blockchain technology to enhance the process. The next section will analyze if the implementation of blockchain will enhance the current proposed solution and, if so, with which features.

6.3 Blockchain model

The proposed centralized database in Section 6.2 offers a first concept for improving *data structure* and *data quality*. Although the centralized database is a helpful tool to overcome both pain points, some challenges arose. To answer the fourth research question: '*What blockchain technology features could be used to improve the current transaction process of an office building?*' this section analyzes which blockchain technology features can enhance the proposed centralized database. The analyzes are based on both literature knowledge and a blockchain expert discussions.

6.3.1 Blockchain consideration

When considering to use blockchain in the proposed solution, it should be analyzed if the solution can benefit from this technology.

'*Blockchains are often sufficient but not often necessary*'. (Koens and Poll, 2018)

To determine what blockchain type is most suitable for this solution the scheme of Koens and Poll (2018) is used. The research of Koens and Poll (2018) analyses 30 blockchain schemes.

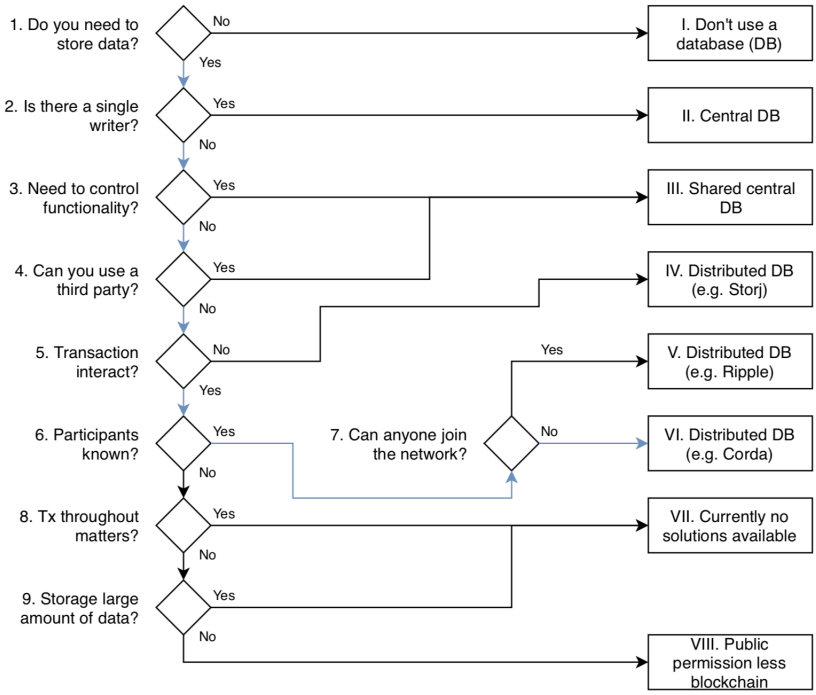

Figure 34: Blockchain consideration. Source: (Koens and Poll, 2018) edited by author.

The scheme of Koens and Poll (2018) starts with the question 'if there is a need to store data' (1, see Figure 34). In the current situation there is a need for a database that stores building related data (technical-, commercial-, financial-, and legal index information). Secondly, in the database there are multiple readers and writers involved (2, see Figure 34). Next, the solution needs to control functionality (3, see Figure 34). Control functionality includes for example setting database permissions (such as create, store, delete). Step four in the scheme includes if the solution needs a trusted third party (5, see Figure 34). External trusted third parties have not been usual during life cycle management and transaction of real estate properties. The next question is about transaction interaction. Transaction interaction is needed due to the validation of multiple actors. However, all actors in the process are known, not everyone can join the network (6 & 7, see Figure

34). Following the scheme a distributed database (e.g. Corda) is most suitable. Corda is an example of a permissioned distributed blockchain database and smart contract platform, which allows involved parties to transact information (e.g. agreements and contracts). Currently, the platform is used in multiple industries e.g. finance, supply chain and health care (Corda, 2018).

According to Section 6.2.2 a centralized database is a helpful tool to overcome the pain points in a transaction process, however some challenges arise as well. As can be assumed from the scheme of Koens and Poll (2018) blockchain technology theoretically can streamline the current process/way of data management. Instead of a centralized database, blockchain works decentralized (Section 3). When in fact, a blockchain database is implemented with application programming interface (API's) between databases of involved parties it ensures that owners and third parties are not responsible for obtaining the data, but the database request the data automatically. Obviously, due to privacy regulations the involved parties will have to grant permission. The documents that are gathered can be registered in the blockchain database. This will result in a complete audit trail, which can be advantageous for advisors, funding, due diligence and regulators. A solution like this can lead to an enhancement in terms of its efficiency, transparency, and can be beneficial to the relationship between parties and an enhancement of the transaction process. Figure 35 schematically visualizes the relation between the proposed centralized database and a blockchain distributed database, also referred to as blockchain distributed ledger.

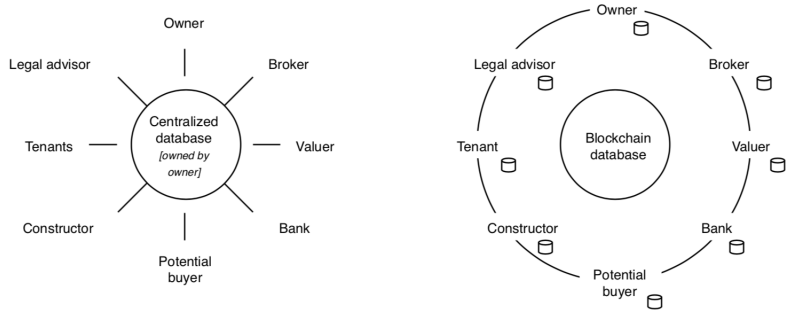

Figure 35: Centralized vs. blockchain database.

After determining that blockchain technology is applicable in this situation and theoretically can enhance the proposed solution, the next section analyses what blockchain features enhance the proposed centralized database.

6.3.2 Blockchain features

In the previous section the applicability of blockchain technology is considered. This section describes what blockchain features could enhance the current way of transacting real estate. First, the functionality and proposed structure of the ledger is elaborated and then the encrypting and consensus mechanisms are further explained. To illustrate the possibilities of blockchain technology characteristics of a permissioned blockchain are used.

Merkle tree

The functionality and structure of a blockchain ledger in the proposed solution can be illustrated by means of a Merkle tree. The implementation of Merkle trees in a blockchain ledger has multiple effects. It enables to scale databases while also providing a hash-based architecture to maintain data integrity and to verify the integrity of data. The proposed centralized database is divided into four indexes (technical, commercial, financial and legal) – as described in Section 6.2. Each index group or (more detailed) number can be allocated to a hash. Hashes store information regarding

the validated framework and attachments in the blockchain. Cryptographic hash functions are the underlying technology that allow for Merkle trees to work. Figure 36 visualizes the proposed blockchain ledger structure of a building.

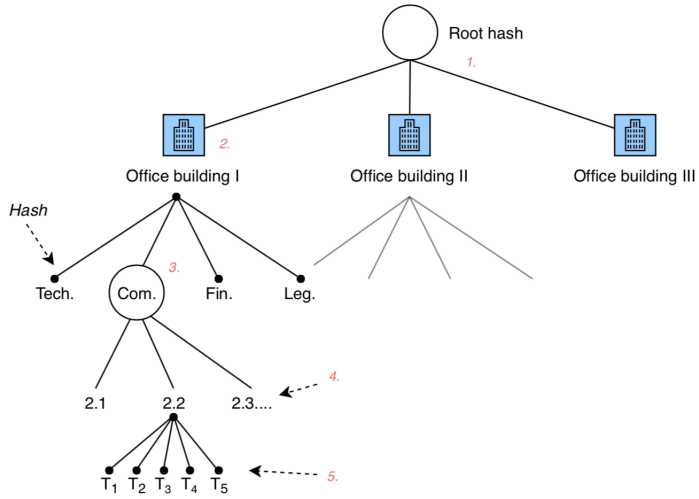

Figure 36: Proposed blockchain ledger structure.

As shown, the proposed blockchain model consists of multiple layers and corresponding hashes. These layers contribute to information layers, which can be outlined as follow:

1. Hash → Building related data
2. Hash → Index related data
3. Hash → Specific index code
4. Hash → Framework (class diagram)
5. Hash → 'Original' data

Merkle trees decouples the proof of the data from the data itself. In order to clarify the practical applicability of the proposed blockchain structure an example within the transaction process is given. Once, a potential buyer – with a generated private key – show his interest for 'Office building 1', the buyer is permissioned to view marketing related data, such as Index 2.2 (lease agreements). Without 'reading' the original contracts itself the potential buyer is capable to verify all signed contracts. In this way, parties can verify specific data without viewing the 'original' files.

Cryptographic audit trail

As described before, the proposed centralized database is divided into four indexes (technical, commercial, financial and legal). Technical index elements are often physical of nature and commercial-, financial- and legal (CFL) indexes contractual. To manage a property during its life cycle, the obtained building information from the previous transaction needs to be stored and modified. Blockchain technology can enhance the process of monitoring modification of existing data by a so called cryptographic audit trail. By implementing a cryptography audit trail information regarding adjustments can be stored on the blockchain. However, due to the large amount of adjustment data, creating an overview could be a challenge. An unclear overview could be solved by implementing visualization software for physical elements. For example, technical

information of a building can be visualized by building information modeling[10] (BIM) technology or another visualization tool. Information regarding physical elements can be made clickable in a visualization tool. The infrastructure of a physical element in a visualization tool combined with blockchain technology is visualized in Figure 37.

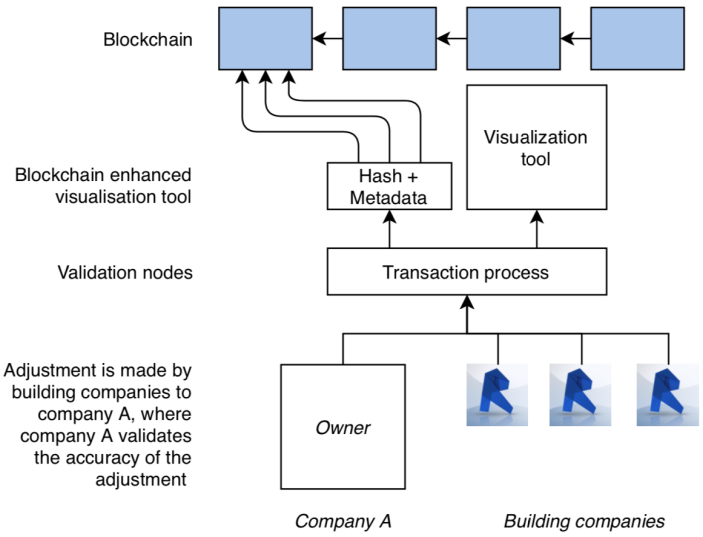

Figure 37: Infrastructure blockchain with visualization tool. Source (Turk and Klinc, 2017, p. 643) edited by author.

However, if all drawing data is stored in a blockchain, the storage capacity of the database needs to be huge. Besides drawing related data, contract data is stored in this database as well. Blockchain technology makes it possible to store only the audit files (hash) – consisting of information outlined in the class diagram – in the blockchain ledger and the original data file is stored in a individual workstation of e.g. the owner. Hence, blockchain technology can be used as an audit trail consisting of hashes with validation data (Figure 26). In this scenario the documents themselves are stored in centralized databases of involved parties and the hash – proof that a certain file exists (Proof-of-Work) – is stored in the chain. Turk and Klinc (2017) stated that: 'It would appear to the client that a file is local while in fact it would be pulled from the blockchain and cached locally if and when needed'. The same applies to contracts within CFL-indexes and processing of complaints. Although, the contracts (original data) are stored on servers of an owner, bank, tenant (lease contracts), valuer or legal company, validation information and corresponding hashes with audit information are stored in the blockchain. The hashing mechanism contributes to the reliability within the blockchain ledger. Since, a validated adjustment is hashed it is highly impossible to change or alter the data within the 'block'. Currently, due diligence processes are executed to validate obtained information. Parties are validating obtained information from each other – this symbolizes the lack of reliability in data. Therefore, it can be assumed that there is a lack of trust during the transaction of an office building. However, if information is hashed – based on the method described above – the due diligence process will be shorter or not be necessary anymore and parties will trust each other. In the new situation a potential buyer requests all building related information which is hashed and thus reliable – validated by external companies without interests in the project. For example, a hash – on a blockchain – consists of a framework (Figure 26 on page 51) and the following hash elements (Section 3.1):

- Hash code – be4771351dec9318fdf43d0dd0a9b183
- Data owner – Company X
- Ledger location – URI
- Governance – Ledger governance & permissions

[10]Building information modeling is 'the process of creating and using digital models for design, construction, and/or operations of projects. Such digital models are meant to simulate the construction project in a virtual environment' (Fountain and Langar, 2018, p. 108).

Besides the hash code, hash owner and location of the data, the data contains information regarding the permission of writing (editing) and reading (viewing) files. Blockchain ledger governance describes who has what rights. Each hash in the database consists of a governance element to define the permissions within the hash and ledger. According to Kembro et al. (2017) defining what information is shared in the ledger with whom is difficult, which reduces the reliability of ledgers. With the use of ledger governance – on the base of encrypting data – access regarding 'read' and 'write' permissions can be managed. Therefore, adjustments that are made and validated in the system are always traceable to the party that is responsible for the specific element.

Cryptographic standardized contracts

The previous section describes encrypting audit trails (record-keeping) as a method to store data (class diagram framework) in a blockchain. Although data regarding physical and contractual elements is stored in the chain, detailed information ('original' document) is stored on a server of the involved parties. Due to the unstandardized way of working validating nodes are essential to validate the information that is add in the blockchain. However, standardization of contracts or agreements contributes to automatically generating information between involved party. For example, contracts or agreements could be automatically compared with a set of requirements and therewith automatically validated. Digitizing and standardizing of elements in the transaction process is a next phase in the implementation of blockchain technology in real estate transactions.

In order to clarify digitizing and encrypting standardized contracts a standard lease model is used for lease contracts: a 'ROZ-model'. ROZ-models are widespread lease contracts in the Dutch office market. A ROZ-model is divided into standard clauses, in terms of digitizing such a contract clauses can be allocated to involved parties or databases. This enables self executing and validating contracts (smart contracts, Section 3.1.2). To encrypt clauses in standardized contracts, the contract needs to be converted to a digital contract in the blockchain. API's can be connected to specific clauses referring to databases of third parties, such as a land registry. The digitization of a ROZ lease contract is visualized in Figure 38.

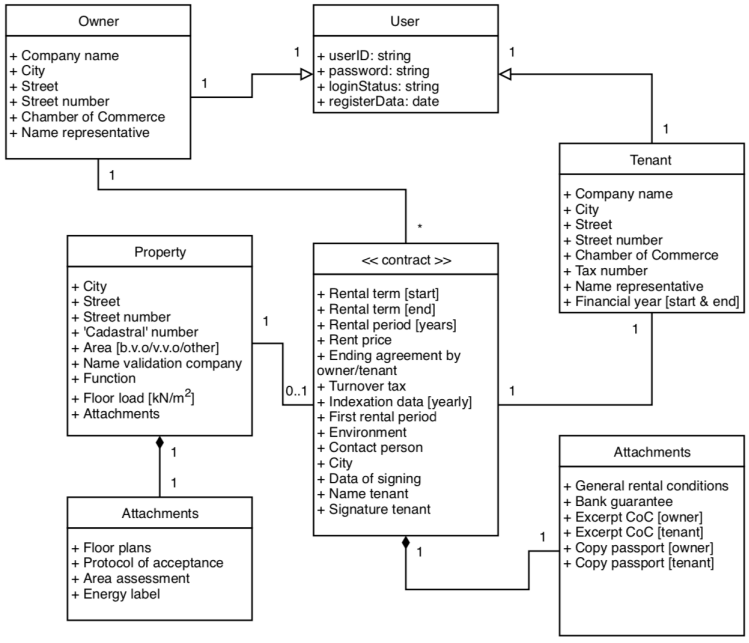

Figure 38: Example of digitizing clauses standardized contract.

All standardized elements of Figure 38 should be digitized by coding to be useful in an automatic validating blockchain database. Once, these coding exist involved parties within the blockchain database are able to get permission for 'reading' and 'writing' specific clauses. Furthermore, a dashboard with specific information can be created by linking elements of the dashboard to digital contracts (tenant schedules, rent income etc. could be monitored and reported). Currently most documents in the real estate sector are unstandardized However, standardization of contracts and agreements could result in an automatic validating and analyzing digital network.

Consensus mechanism and validity rules

Within the proposed centralized database the property manager is responsible for the validation of physical and often contractual adjustments. Thus, after receiving documents, the quality of work (data) is the responsibility and reliability of one person – the property manager. As mentioned by all interviews, *data quality* is a major pain point within the real estate sector. Therefore, validation of adjustments is essential within the life cycle management of a property.

In the proposed blockchain network Poof-of-Authority (PoA) and validity rules can be used. Within the ledger some nodes (trusted signers), also referred to as validating nodes, are exclusively allowed to create and validate new blocks and secure the ledger. Those nodes will receive a set of private keys that are used to 'sign' the new block. To enhance the quality of the ledger a group of nodes will have the exclusively permission to validate data by a digital signature. For example, banks can validate lease contracts, a plumber collaboration can validate plumber related adjustments, etc. It is assumed that minimal 51% of these nodes should agree for the validation of an index adjustment to reach consensus. This means that some parties in the real estate sector should change to a more validating role.

Besides, the validating nodes, involved parties with the authorization rules to write (edit) are able to validate their activities with a digital signature before the information is sent to the validating nodes.

6.3.3 Challenges blockchain model

This section elaborates what blockchain features can be implemented in the model that is proposed in Section 6.2. Although, blockchain technology can enhance trust between involved parties and security in the database by its consensus and encrypting mechanism, there are some challenges to overcome.

Real estate is a non-digital asset, therefore oracles are needed to validate information in the blockchain. Today's commonly-trusted institutions (e.g. Banks, 'Rijkswaterstaat', Chamber of Commerce etc.) can supply digitally signed data feeds that are used by oracles in various blockchains for example take care of automatic insurance, but as indicated above, a designated person with the correct authority can also fulfill this role. Currently, the real estate sector is not organized for such validation roles. A challenge can be the designation of validating nodes in the network.

Another consequence of a non-digital asset are unstandardized contracts, agreements etc. In order to automatically validate, technical standards and a general taxonomy should be created to form the basis of documents and set requirements for specific elements. Reason for this is to let the blockchain solution connect and communicate to other systems with API's. Currently, parties in the real estate sector are using their own systems, (information) formats and corresponding taxonomies. Therefore, standardization in the real estate sector can be considered scarce because many different companies are using different infrastructures and systems. A large number of organizations need to collaborate to simultaneously implement blockchain as a solution in their businesses.

Additionally, governance of the permissioned blockchain is hard to define. For example, '*who is the owner of the blockchain?*'. Fundamentally, owning something means that one has the power of control the database. In a permissioned blockchain a central authority assign permission to participants in the network, and participants only see hashes (transaction history) to which they have access. Thus, in case of a permissioned blockchain a limited number of participants own the blockchain. Currently, there are multiple blockchain governance models possible. Analyzing what governance model works best, is out of scope of this research. However, it is interesting to conduct future research to what governance structure works best in this kind of blockchain network.

6.3.4 Conclusion blockchain implementation

The proposed centralized database in Section 6.2 offers a first concept to overcome the mentioned major pain points regarding *data structure* and *data quality* in the transaction process of an office building. Although the proposed centralized database overcomes both pain points, some challenges arose. In turn, this section concluded that blockchain technology can be a helpful technology to overcome the major pain points and centralized database related challenges. The implementation of blockchain technology is analyzed based on the characteristics of a permissioned blockchain.

It can be assumed that the implementation of blockchain technology enhances the reliability between involved parties and security within the database by its consensus and encrypting mechanism. The proposed database is a distributed ledger – a ledger that is distributed across multiple parties (Figure 35) – which structure and functionality are explained by means of a Merkle tree. This 'sharing' technology enhances the security of data in a network, as explained in Figure 36. Furthermore, a distributed ledger gives control of all building related data to the involved parties and promotes transparency. Within this database a cryptographic audit trail stores validated data in hashes (hash code, data owner, ledger location, governance and framework). Before the data is sent to validating nodes, parties within the network verify the data by a digital signature. Validating nodes – who create new blocks – reach consensus on the basis of PoA. This all together makes blockchain a helpful technology to overcome the mentioned pain points by the literature and interviewees. A record-keeping blockchain is a first step towards digitization of the real estate transaction process. By implementing blockchain technology in the proposed structure parties can properly define what they are actually buying and selling by analyzing the validated record history.

Although blockchain technology is a helpful tool to overcome the mentioned pain points and challenges of a centralized database, some challenges arise by the implementation of blockchain technology. One of the mentioned challenges is the lack of standardization in the real estate sector. If standardized contracts and processes will be more common, cryptographic standardized contracts can be implemented. in turn, API's can connected to specific clauses referring to external databases, such as a land registry when reviewing a lease contract. From this perspective the blockchain database can be much more detailed and requesting information automated, which offers many possibilities for the future of transacting real estate.

6.4 Centralized database vs. Blockchain database

As defined in Section 6.2 and 6.3, both databases are helpful to overcome the mentioned pain points deriving from the theoretical framework and interviews. Figure 35 visualizes the main differences between the proposed databases: centralized database, blockchain audit trail and future blockchain standardized audit trail.

- The proposed centralized database is relatively easy to develop and maintain. Although, all data can easily accessed form one sever, a lot of computing power is needed to store all building related information. Data quality and structure is guaranteed by validation protocols and coding of adjustments and revisions. However, some challenges arise as well, such as a single point of trust and security issues.

- Implementing a blockchain audit trail is a helpful technology to overcome the mentioned challenges of a centralized database as well as the pain points. The decentralized database stores only validation information, the 'orginal file' is stored at a server of the third party – as the current situation. The information is validated by the third party, owner and a validating oracle in the network. A decentralized database mainly increase the reliability and security in a network. As outlined in the previous section relation between parties could be enhanced. Record-keeping in real estate management is a first step toward digitizing the real estate transaction process. Involved parties can 'read' and 'write' specific information needed to come up with a final bid.
- Due to the lack of standardization in the real estate sector and subsequent processes, oracles are needed to validate information. If standardized agreements, such as a ROZ-model, are more common validation of adjustments can be done automatically. Requesting and validating information automatically offers many possibilities for the future of transacting real estate.

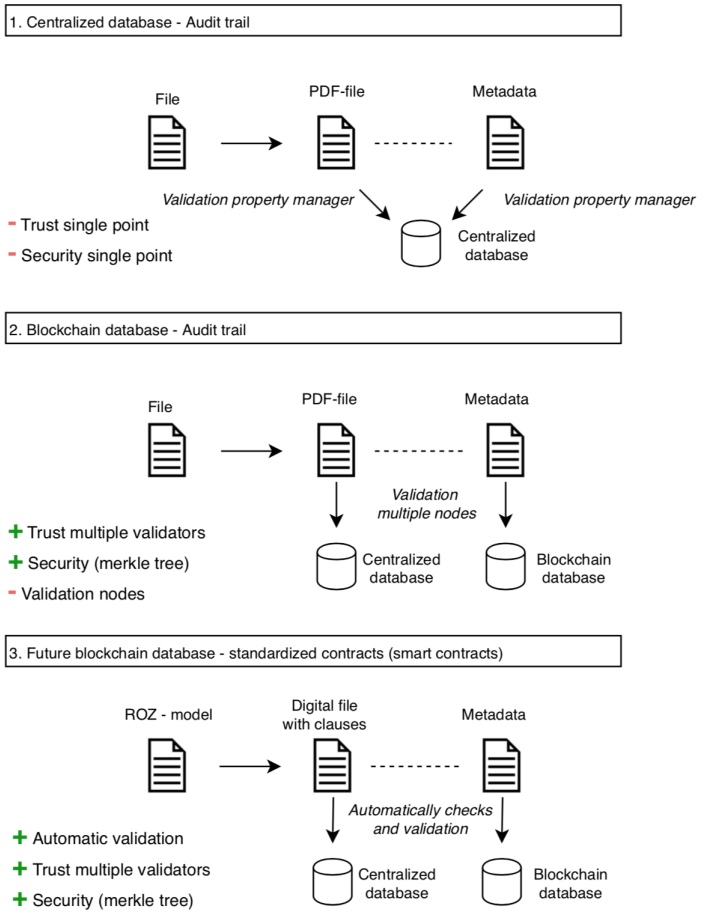

Figure 39: Centralized database compared to blockchain database

According to above comparison the development of a common centralized database enhances the current transaction process. However, challenges related to reliability and security within the network arise. Reliability, also referred to as trust, in the network is one of the problems that occurs in real estate transaction – derived from the multiple due diligence phases in the transaction process. Blockchain technology is capable to enhance the current way of transacting real estate as well as to overcome the challenges of a centralized database. However, due to the immaturity of the technology, lack of standardization, legal challenges and limited application examples, blockchain

is still in his infancy. Hence, developing and implementing a blockchain application is complex. The potential of blockchain technology and automatic validation could be valuable of transacting real estate. When implementing blockchain technology it is essential to develop a core database, based on this core standardized agreements and other API's could be developed in the future. It can be concluded that blockchain technology could be a new method for managing physical and contractual building information in a structured and reliable way, where a centralized database seem rather unlikely to be able to enhance the current process.

6.5 Summary

In the previous chapters a theoretical framework is drafted and the empirical findings are elaborated. It can be concluded that there are two major pain points during the process: data structure and data quality. This chapter describes a solution which improves the CRE transaction process. In this way, the fourth research question can be answered: '*What blockchain technology features can be used to improve the current transaction process of an office building?*'.

Blockchain technology is simply a new method of structuring and handling data – a new type of database – which is often suitable but not often necessary. However, streamlining transactions and data by implementing blockchain technology could be help overcome the aforementioned pain points and challenges. To determine which blockchain technology features can be used, a solution without blockchain technology is proposed in the first place. Based on this solution it is analyzed if blockchain technology enhances the current solution, and if so under what features. To overcome the major pain points in a transaction process without the use of blockchain technology a centralized database is proposed (Section 6.2). It is assumed that – after buying a property – the owner of the centralized database stores all (validated) property related data in the database. Subsequently, the owner has the possibility to monitor the adjustments during the life cycle of the property (life cycle management). Each involved party will get a private authorization key, which makes adjustments traceable and parties liable without discussions. Furthermore, to guarantee data quality within the system all adjustments needs to be validated by the involved parties with their private key. After the validation of an adjustment, a framework file will be created to monitor all essential information. Although working in a centralized way is helpful to overcome the pain points, challenges such as reliability, transparency and security of data arise. These challenges mainly occur due to data being stored on a server owned by one party.

Based on aforementioned pain points it could be assumed that a reliable audit trail of files could improve CRE transactions. Therefore, it is analyzed if blockchain technology could improve the process, and if so with what features. The structure and functionality of the proposed system is explained by means of a Merkle tree. The database is structured according to the data requirements of a transaction, which is split into two elements (indexes):

- physical (technical) elements
- contractual (commercial, legal and financial documents) elements

Grounded on this tree a cryptographic audit method is proposed. Physical and contractual data can be logged on a blockchain based on its consensus mechanism and cryptographic encrypting method, also referred to as cryptographic audit trail or hash chain. The proposed audit trail keeps track of, in a log file (class diagram framework), which adjustments are made towards the 'original' files. After validation by external nodes (oracles) these log files with adjustment related information are added to the database. The original files are stored on the servers of the involved parties and validation information (framework) is uploaded in the blockchain. The validated framework consists of all essential data elements of a file (e.g. index code, validation date etc.). By implementing this technology parties are able to monitor their property based on record-keeping. Validated record-keeping is the first step towards creating digital real estate transactions and resolving the pain points in the process.

Although, blockchain technology is what builds digital records of physical and contractual information, it does also come with challenges. These are as a result of the immaturity of the technology, a lack of standardization and limited examples of successful application. Hence the implementation of the proposed model is quite complex. Currently, the correctness of documents need to be validated by validating nodes (oracles) in the network, due to the lack of standardization. For the system to add value, data such as reports and inspection frameworks must be standardized. If this is possible, the record-keeping application could be linked to external databases (sources) by way of an API. Therefore, data could be automatically validated without the need for oracles, and analyzed by the user. Also, authorization rules in the network could be much more detailed (e.g. data such as contract clauses could be recorded). All this could make the proposed application suitable for managing physical and contractual data, which, consequentially, could enhance the transaction process.

Chapter 7

Implementation & validation

In the previous chapter a blockchain technology based database is proposed – based on underlying frameworks of the mentioned centralized database. This chapter aims to validate the proposed solution and hence answering the fifth research question, which reads as follows: '*What does an office transaction based on the proposed blockchain model look like?*'. Before validating the model, it is determined – according to a prototype – what the new process will be (Section 7.1). According to this visualization the model is validated by semi-structured interviews (Section 7.2). After validation of the proposed model the final research question is answered as well, which reads as follows: '*What could be the potential role of a bank in a blockchain based transaction?*'. Section 7.3 discusses the potential role of the bank. Finally, this chapter is wrapped up in Section 7.4 with an answer to the research questions as posed above.

7.1 Implementation

To determine '*What does an office transaction based on the proposed blockchain model look like*?' the new process is visualized by means of a back-end and front-end prototype. Blockchain technology is a method for structuring and handling data in a network, what takes place in the software of the platform, also referred to as 'back-end' infrastructure. The proposed blockchain database has the potential to change the way real estate is transacted. The diagrams and figures in this section visualize the infrastructure and interaction between involved parties in the blockchain network.

7.1.1 Blockchain transaction model

To illustrate the proposed blockchain solution the back-end infrastructure is visualized. The improvement of the transaction process of an office building starts with the structure and quality of input data. In Figure 26 and 31 frameworks are outlined. Each data element in the network should fulfill the elements of these frameworks. As stated before, the 'original' files (e.g. PDF-documents) are stored in databases (e.g. cloud based, central server) of the data owners. In contrast, the framework is stored in the blockchain network (Figure 40). The hashing infrastructure forms the foundation of the blockchain model and is part of the merkle tree (Section 6.3.2).

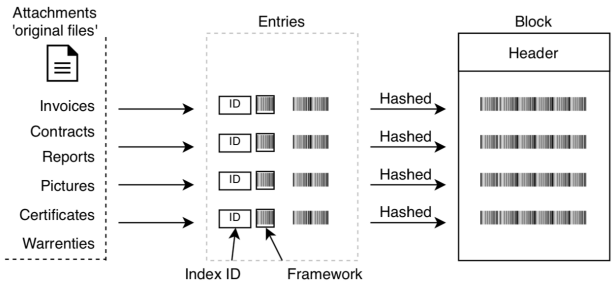

Figure 40: Hash infrastructure.

After the framework is filled with information and validated by the owner – or property manager acting on behalf of the owner – and third party the information is send to external validating nodes, called oracles. Oracles check all the requirements of the documents before the data is hashed and uploaded in the network. The process of adding new information to the blockchain is based on the transaction flow described in Section 5.1.

To elaborate the back-end infrastructure of the application in more detail, the interaction between involved parties in the network is visualized. In the first instance, the proposed solution is used during the operation phase of the property. This mainly enhances data structure and quality related pain points within the real estate sector. Hence, specific information and reports can be selected and loaded from the database to be analyzed. For example, blockchain could be used to record adjustments and revisions what subsequently enables involved parties obtaining specific validated information when needed. In order to clarify the practical applicability Figure 41 visualizes a *physical adjustment* in the blockchain network.

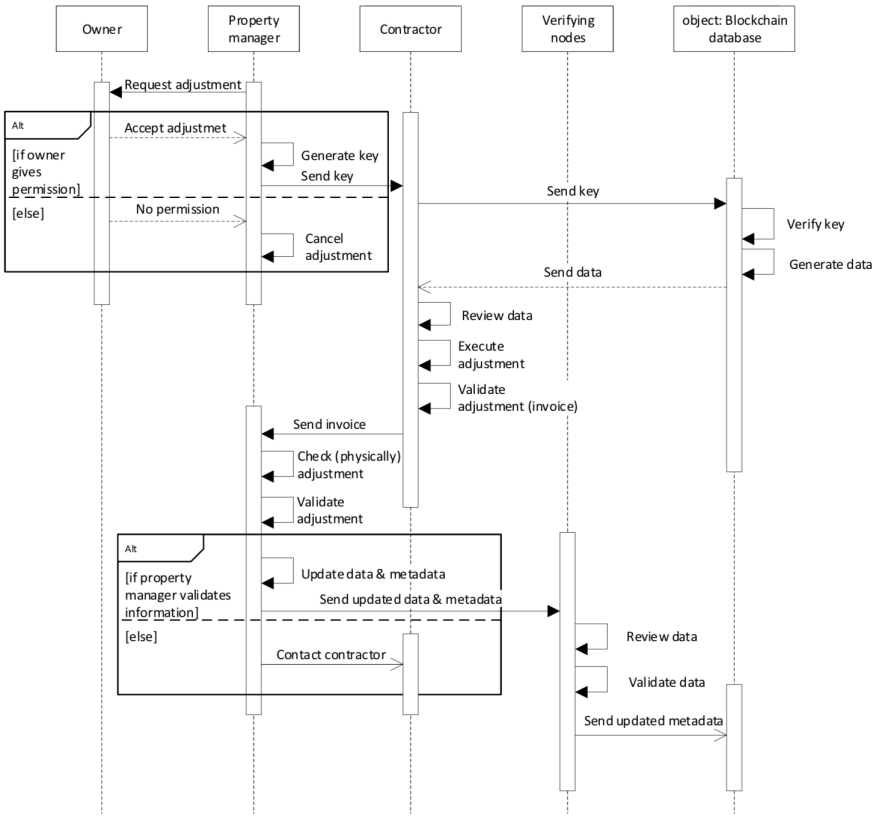

Figure 41: Example of physical adjustment blockchain ledger.

As an example of a physical adjustment it is assumed that roofing material of an office building is replaced. Once the owner gives his permission to replace the roofing material, a property manager (who is responsible for all physical related adjustments, Appendix E) generates a private authorization key, including a permission rule set for a contractor to view specific data in the database. Now the contractor is able to review reliable information related to the roofing replacement, such as material, surface etc. The chance of additional cost could be reduced in the enhanced situation due to reliable data. After execution of the replacement the contractor sends a verified invoice to the property manager which, in turn, checks and verifies the adjustment. This result in a framework including all information regarding the adjustment which, in turn, is sent to verifying nodes in the network (in case of roofing replacement it can be a collaboration of external contractors) –

who verifies the adjustment and sent the updated information to the blockchain database. This process enables record-keeping in a digitally, reliable and secured way. Record-keeping in the proposed system is able for all physical and contractual related documents from invoices to health certificates of an elevator and from a physical adjustment to lease contract revisions.

Although record keeping in the proposed solution enables involved parties to select specific information and reports, for validation of documents oracles are needed. Currently, physical data and contracts (agreements) are standardized nor digital. Therefore, oracles, a reminiscent of a trusted third party, play the role of 'source of truth' in the proposed database. Thus it can be assumed that digitizing and encrypting standardized contracts goes a step further in digitizing building and contract adjustments, revisions, modification etc. Once documents are standardized and digitized, API's could be connected to specific clauses referring to external databases, such as a land registry or bank registry. In this perspective the blockchain database could be much more detailed and automated what offers many possibilities for the future of transacting and managing real estate.

Currently, the proposed blockchain database enhances the current transaction process due to its ability to structure data – according to an index structure (Appendix F) – and guarantee quality by encrypting and consensus methods. Although the transaction process of an office should look like almost the same compared to the 'current' situation, reliability between parties and security within the network will be enhanced. As stated before, it would appear to the requesting party that a file is local while in fact it would be pulled from the blockchain and cached locally when needed (Turk and Klinc, 2017). Figure 42 visualizes the proposed transaction process. Although all elements are almost the same as in the current process it could be assumed that the due diligence and negotiation process will be reduced in time by the implementation of this database, due to the enhancement of trust between involved parties and reliability of information. Hence, the proposed solution enhance the current transaction process.

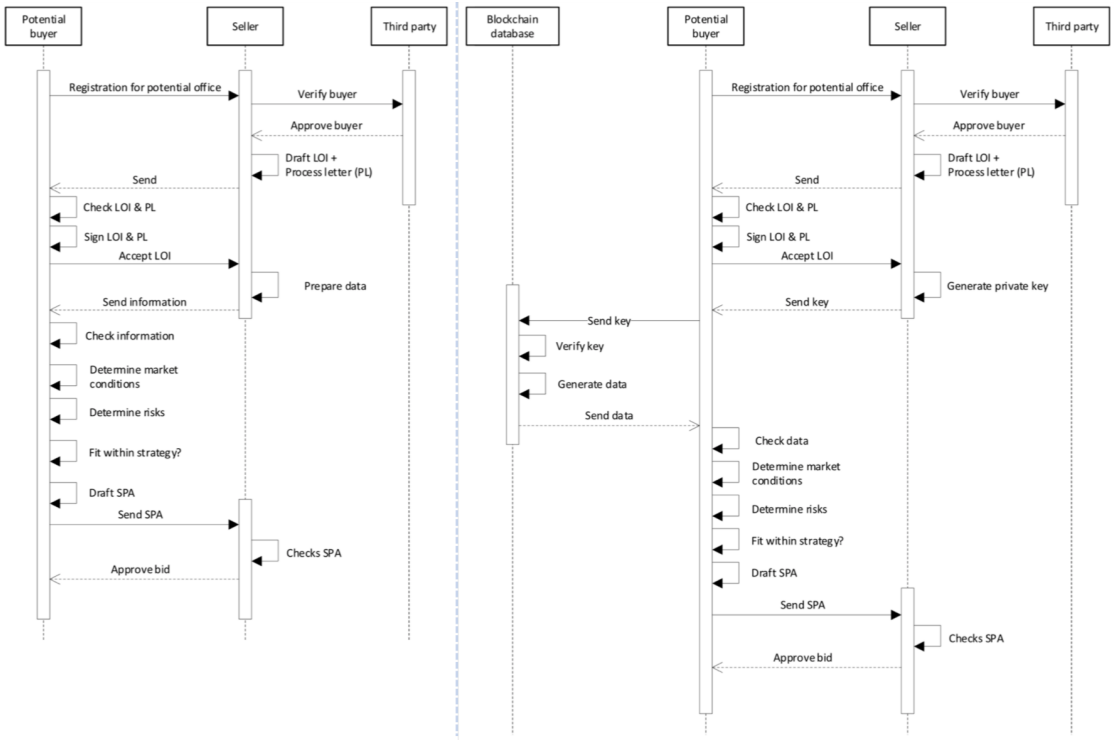

Figure 42: Current (left) and proposed (right) situation regarding the office transaction process.

7.1.2 User interface

For the full version of the (clickable) user interface, please contact the author.

On top of the proposed blockchain data management infrastructure (back-end) a conceptual front-end is developed. The front-end of the proposed data management solution is visualized by means of a clickable user interface (UI) prototype. The UI enables future users to evaluate the back-end solution. This contributes to the validation process of the next section. The proposed front-end is an example how the underlying data infrastructure could be visualized for future users. Although, it is possible that in the future various parties develop a front-end application based on the underlying proposed infrastructure, this research proposes an initial front-end – based on the proposed back-end.

Within the proposed data management solution multiple record-keeping process flows can be distinguished.

1. Owner/admin (or on behalf of the owner a property manager)
2. Potential buyer
3. Third parties (e.g. tenant, contractor, bank etc.)
4. Validating nodes (collaboration of contractors or property managers)

Due to the focus of this research – improvement of the current transaction process of an office building – the UI mainly lies on the perspective of the owner of the office building and potential buyer. However, as aforementioned the role of a property manager is essential to guarantee data quality and structuring data. Therefore, in combination with the flow of an owner the flow of a property manager will be discussed.

Before discussing the UI flows, the initial situation of the application is outlined. Interviewees aforementioned that pain points specifically derive from data structure and quality and can be allocated to the preparation phase in the transaction process and the management of the real estate once the property has been acquired. One could imagine that data obtained once the property has been acquired should be uploaded – based on the proposed structure (Appendix F) – and validated in the proposed application. Literature states that the proposed structure represents the minimal level of information needed for a transaction. It may occur that not all documents are available given the proposed structure. The proposed structure supports improving the transaction process. The level of information could be reflected in the (transaction) price of the property once an owner is not able to satisfy the minimal level of information. Hence, for an owner it is important to acquire all relevant information during the acquisition of a property. Management of physical and contractual information starts once the property has been acquired and information is structured according to the proposed format. All involved parties receive a private key (login code). With a private key authorization rules can be assigned to specific parties. For example, an owner of the building, also referred to as admin, is able to view all physical and contractual information. In contrast to the owner, a tenant is only able to view his lease contract – other contracts (e.g other lease contracts, title of ownership, managing agents' contract details etc.) and physical elements are invisible (locked) for a tenant. So, each party and file has different authorization rules (write, read and locked).

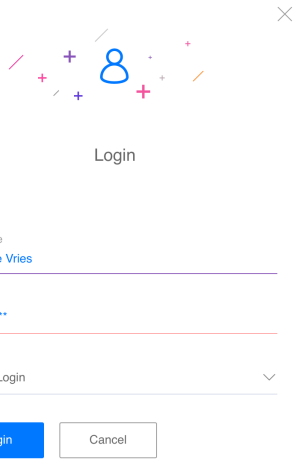

Figure 43: Login UI.

The UI is extensively discussed from an owners perspective. On the base of the owner UI other network perspectives will be illustrated. To open the application a username and password are required (Figure 43). The owner is able to add a building to the blockchain network, as visualized by a Merkle tree in Section 6.3.2. After the owner logs into the application a dashboard screen will appear (Figure 44 on page 72). The dashboard shows general information regarding a selected office building or a more extensive overview of the overall portfolio, such as total annual income, occupancy rate, median income, number of objects and number of tenants. Furthermore, the properties are visualized in a map and could be selected for more property related information (e.g address, construction year, area, energy label, market value, occupancy rate and rental income). More important are the selection tabs on top of the figure and the activity section at the bottom.

The tabs at the top of the figure are related to physical elements, contractual elements, network parties (contacts), reports and access. The yellow circles indicated that some activities need action. In line with these activities is the section at the bottom of the figure: recent activities, current activities (this week) and overdue activities. All activities could be grouped according to an index number as purposed in Section 6.2.1 and a more specific code – the physical elements are code based on the linked data method. The recent activities could be show in more detail in the activity screen (Figure 45). Activities could have multiple statuses: pending, verified and validated. If an activity has the status pending the involved parties should validate the specific action. After validation the status will switch to verified. A verified action means that both parties (e.g property manager and contractor) agreed upon the action. Only validation of external oracles (e.g. collaboration of contractors or a bank) is needed if documents are not standardized. In case of standardized documentation, oracles could be replaced by API's linked to external databases for checking the requirements in the specific action. From Figure 45 it could be stated that the owner of the building is authorized to view and verify all activities regarding the property. However, creating new blocks (validation) needs to be done by validation nodes in the network.

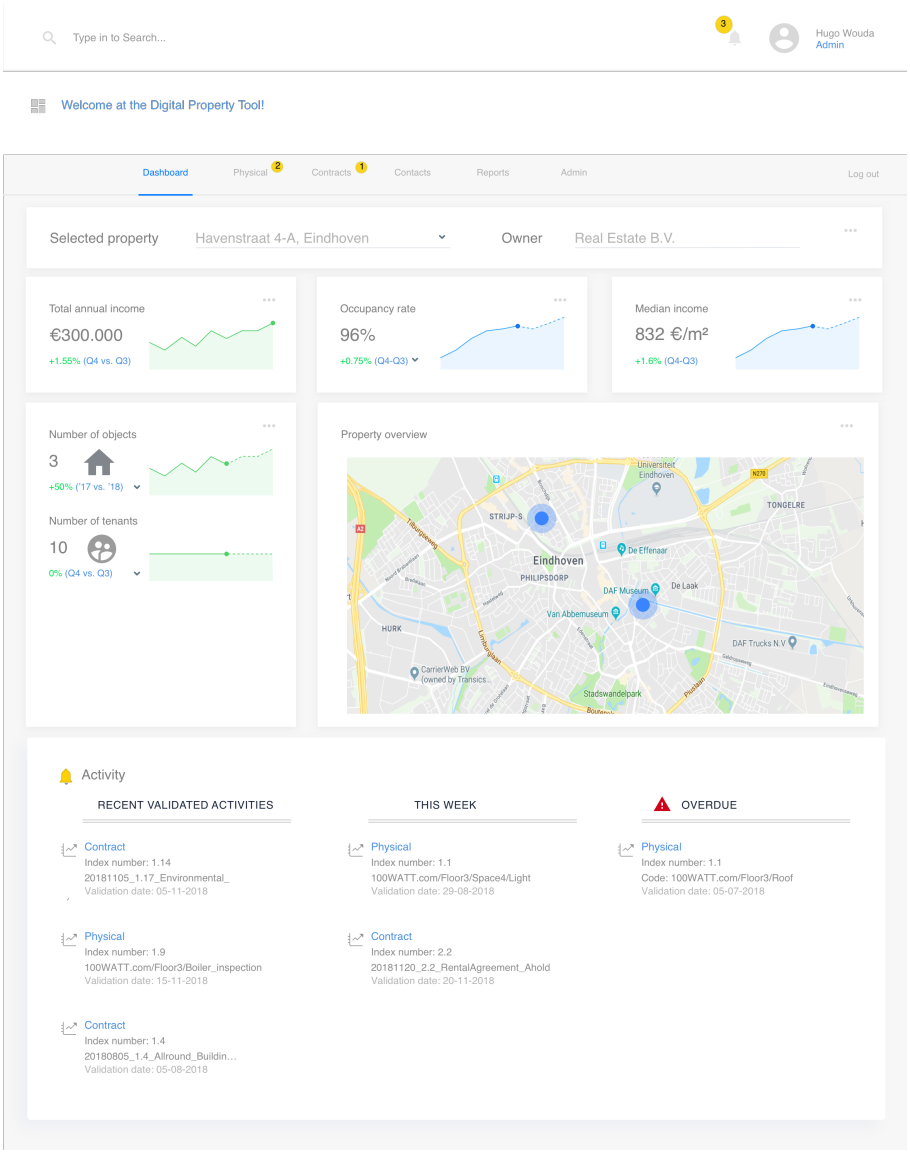

Figure 44: Dashboard owner.

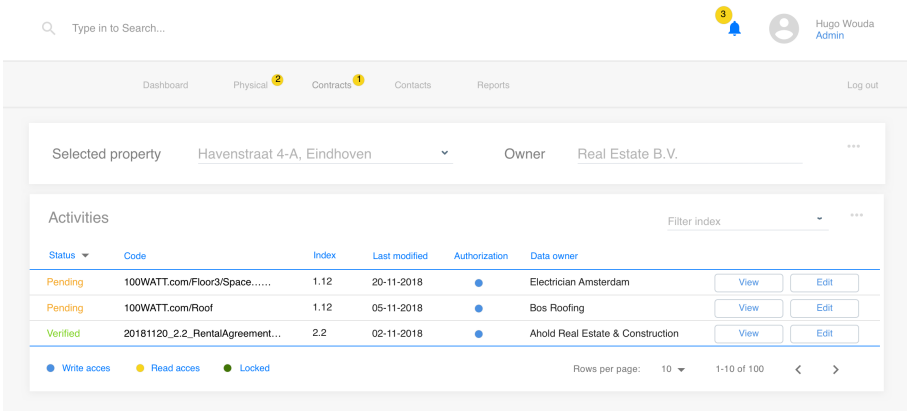

Figure 45: Owner action messages.

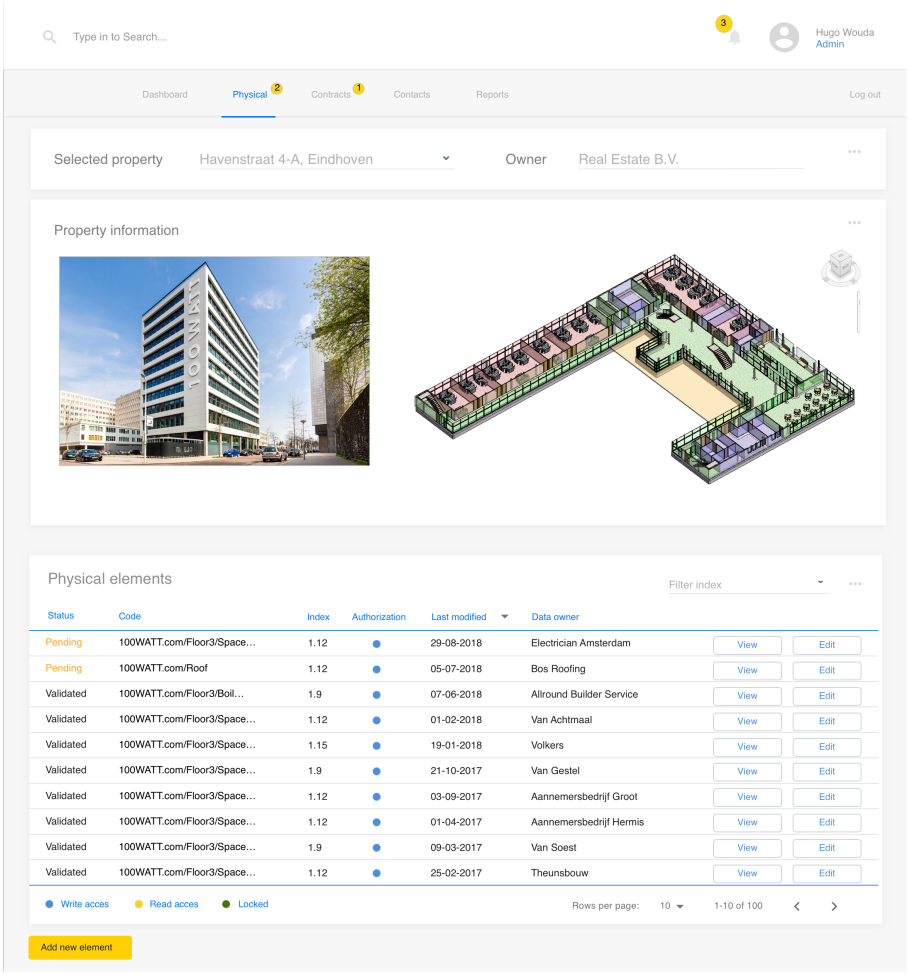

Figure 46: Owner physical elements overview.

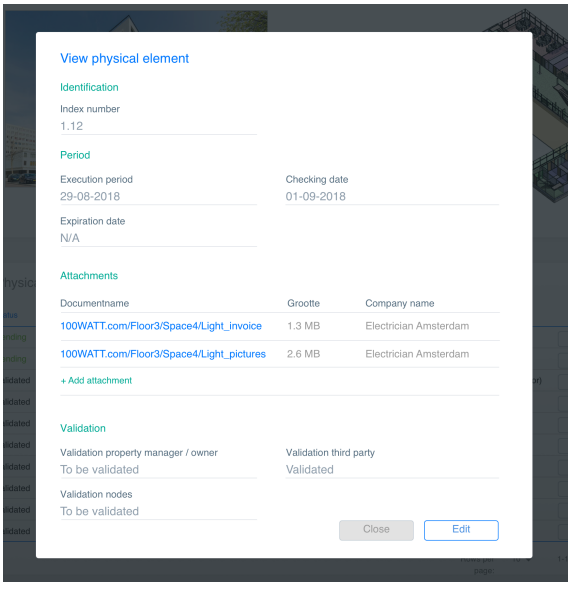

Figure 47: View physical element.

By using the tabs at the top of the application the owner could select to view physical or contractual activities. Figure 46 visualizes an overview of all physical elements in the blockchain network. From the figure it can be concluded that the owner is able to read and write (edit) all documents or add a new physical activity (e.g. changing the lights in the building or request an inspection). To view, verify or edit an activity the owner can click on the 'view' or 'edit' button. Figure 47 visualizes an activity that is validated by a third party and needs an action from the owner. The framework of physical activities is based on the class diagram of Figure 26 on page 51. This class diagram is translated in Figure 47 to a front-end page. As can be seen in both figures the data owner of the first activity is 'Electrician Amsterdam'. However, the data is stored on the owners server after verification as well.

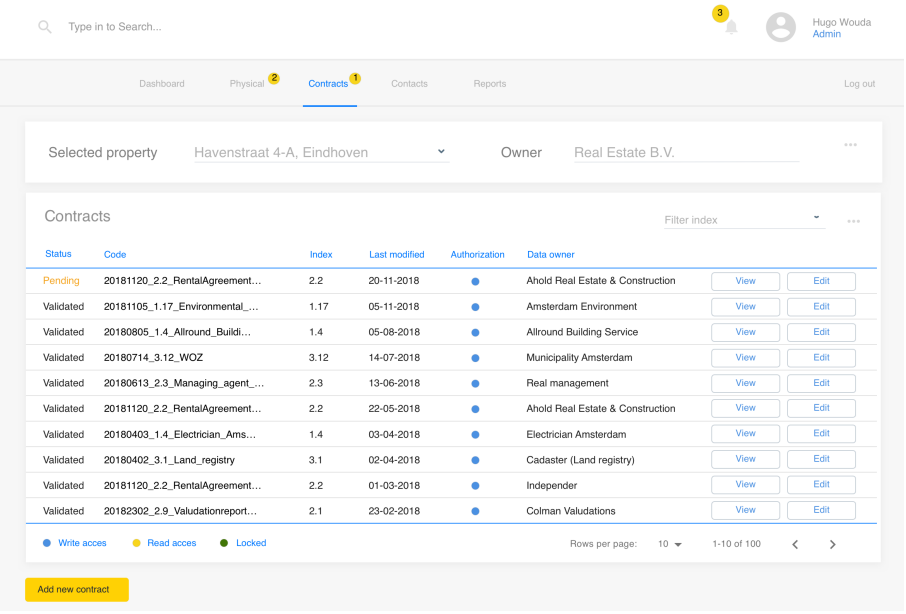

Figure 48: Owner contract overview.

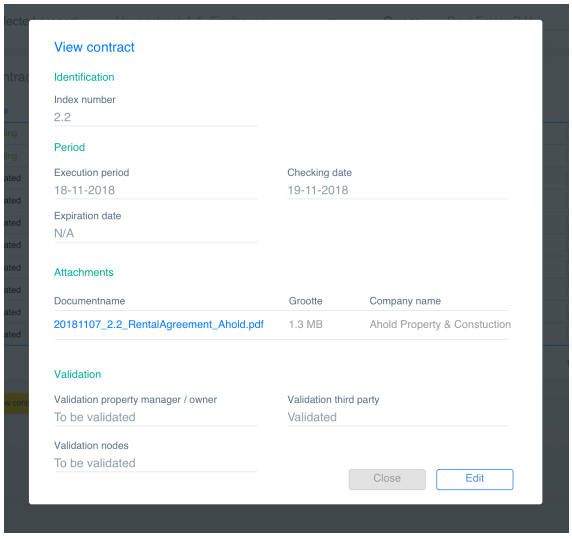

Figure 49: View contract.

Compared to physical activities, the same applies to contractual activities. Figure 48 visualizes the front-end contractual activity overview. All activities are coded according to the index of Appendix F. The framework of contractual activities is based on the class diagram of Figure 31 on page 54. This class diagram is translated into a front-end page visualized by Figure 49.

As can be seen in all figures (Figure 46, 47, 48 and 49) data is owned by a third party. However, after verification by an owner, or a property manager acting on behalf of the owner, the data will be stored on the owners server as well. This avoids problems with deleting files without permission of two parties. In the proposed application 'original files' are stored on servers of two involved parties and class diagram related information in the blockchain network. This allows parties to view specific information on behalf of their function in the network. Currently, data is stored by two parties as well. However, structure is missing due to the decentralized way of working. The framework leads to a more transparent and organized way of managing data.

In addition to the authorization to write and read physical and contractual activities, the owner – or property manager acting on behalf of the owner – is able to assign authorization rules to parties within the network. Although, the owner has all 'power' in the network to assign documents to parties, parties see a hash code if a document is locked upon which parties can contact the owner why they have no authorization to read a document. This is explained from a potential buyers perspective on the next page.

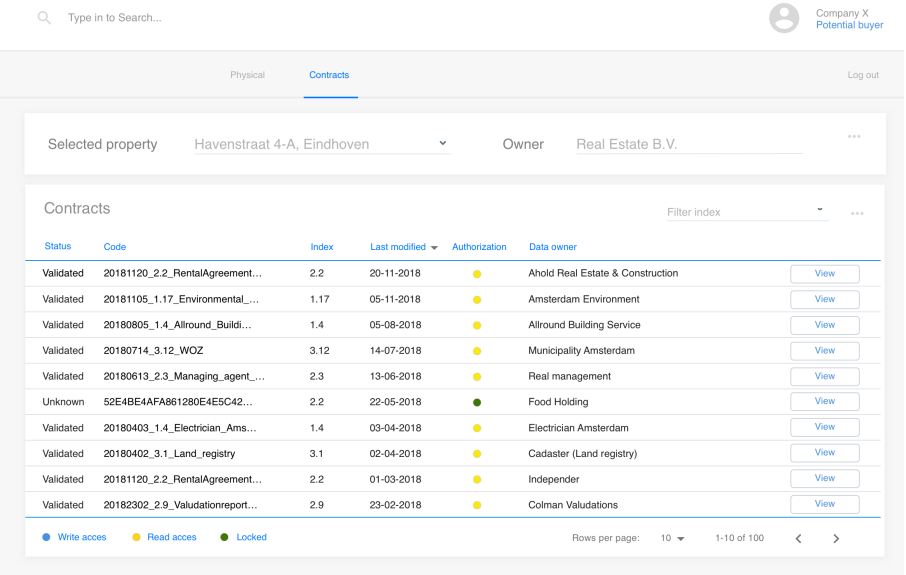

Figure 50: Buyers contractual overview.

From a potential buyers perspective all physical and contractual related files should be readable. As could be noticed form Figure 50 the document owned by Food Holding is locked. In this case the potential buyer can see that a documents exists, but the owner withhold information. The potential buyer can get in touch with the owner of the property regarding the specific file or call the reliability of the owner into question. In this way the transaction process could be much more efficient. The owner can prove that the buyer is able to see all physical and contractual property information and the buyer can rely on the quality of the documents.

With this UI a front-end concept for a prototype is proposed. In the current situation documents are not standardized whereby connecting API's – to data elements – is impossible. Due to the lack of standardization in the commercial real estate sector physical and contractual related documents are stored as a PDF-file. Thus, in this situation the proposed application is mainly a data management application. Therefore, the proposed application serves as core – with an interesting underlying blockchain infrastructure – for future digitizing and enhancing of the current transaction process. Assuming that the real estate sector focuses on standardization of physical and contractual documents, API's can be connected to the proposed blockchain infrastructure in the upcoming years. As can be concluded standardization is one of the focus areas to optimize the proposed application.

7.2 Validation

The previous sections discussed the back-end and front-end (user interface) of the system. The aim of the research is to develop a solution that can be used to improve the current situation. For the blockchain model to be deemed acceptable, this research makes use of pragmatic validation to ensure that the model resolves the identified pain points. Dresch et al. (2015) stated that 'the premise of design science is that the research conducted under its paradigm, in addition to being rigorous and scientifically valid, should also seek pragmatic validity, i.e., utility. In this context, pragmatic validity seeks to ensure that the solution proposed to solve a particular research problem will, in fact, work, which will ensure the achievement of the expected results' (Dresch et al., 2015, p. 57). Therefore, the interviewees (Round 1) are asked again to pragmatically validate the proposed model (Round 2). Successful implementation of the proposed tool depends not only on the benefits that may be achieved for a bank, but for other involved parties in the network as well.

In this section the outcomes of this validation and the potential benefits for the involved parties are discussed. Besides the participants of Round 1 an interview with an blockchain enterprise architect is conducted to reflect from a more technical perspective. During the validation the current situation is compared with the proposed situation by a property manager, head of investments, financial- and IT advisor and an enterprise architect.

Property manager
From validating the proposed tool by a property manager of office buildings it could be concluded that record-keeping of building information is an interesting first step towards the digitization of building related information. Furthermore, it could enhance the current way of managing information. This is particular important from a technical point of view by administrating inspections, maintenance and complaints – analyzing data. From a personal point of view the property manager indicates that the added value of the proposed tool may be higher in residential real estate, due to the amount of revisions in contracts and hence physical adjustments.

> *"The tool could be interesting for large pension funds who benefit from stability and transparency."*

From a property managers perspective the added value of the tool is the reliable and transparent way of administering activities during the operation phase – life cycle of a property.

Head of investments
During the validation with a head of investments (broker), acting on behalf of the owner, the added value of the application is the improved transparency, reliability and efficiency. Submitted data is of higher quality and structured in a proper way, whereby it is more easy to evaluate a property. Parties themselves are able to analyze the data in their own way with their own API's.

> *"It is still important to question yourself what the proposed tool improves and what is in it for all involved parties."*

This implies that before developing the proposed tool it is important to evaluate its added value for all involved parties. Although, the broker is enthusiastic about the proposed tool, some challenges arise as well. No matter how digital people live today with all possibilities, human input is essential. However, by using the application fewer mistakes will be made. Therefore, the application in combination with standardization of documents is interesting for the future of real estate management and consequently transacting real estate (e.g office buildings).

Financial- and IT advisor
The interviewee described the proposed application as an application for the ideal workflow.

> *"In this way the current transaction process will be bottom-up improved. On the one hand, the application is helpful to overcome quality related challenges and on the other hand it improves transparency in sharing data"*

However, the implementation of the tool is seen as biggest challenge. Currently, software companies and advisors benefit from lacking transparency and unstandardized documents. It is essential to investigate the added value of such an application for all parties. Furthermore, standardization is seen as one of the biggest challenges. Institutions (e.g banks and AFM) or sector wide organization with a large market coverage should take the lead in standardization of documents. Reporting to those institutions is important in the development of standardized documents and formats. Although the mentioned challenges, the interviewee sees the application as first step toward a more digital ecosystem.

Enterprise architect and blockchain expert
In contrast to the interviewees of Round 1 an extra interview is conducted – with an enterprise architect focusing on ecosystems in combination with blockchain – to reflect on the technical aspects of the proposed infrastructure and application.

The interviewee indicated that the proposed infrastructure and UI are technical feasible models

that enables the improvement of the real estate ecosystem, and therewith the real estate transaction process. However, some challenges arise. The main challenge is how to connect sources to physical and contractual documents. Furthermore, a challenge is the scope of the application. Although the proposed infrastructure resolves pain points in the transaction process, defining data management is essential in the first phase to re-structure an ecosystem. Data quality and structure are essential to improve internal workflows of companies and for future innovations. Therefore, someone should take the lead to develop the (standardized) infrastructure. Based on the infrastructure parties can connect sources and develop analyzing tools for internal workflows.

"...high dependency on standardization of documents."

The proposed infrastructure and standardized documents in combination with a tool that specializes in data analyzes and aggregation (advanced analyzes) looks promising. The proposed application forms the core of future applications in the ecosystem. A digital ecosystem starts with having structured and high quality data. From that point parties could develop application to do analyze the available data.

7.3 Role of the bank

This research is conducted in collaboration with a dutch bank. Therefore, this section will discuss the potential role of the bank in the proposed solution.

Nowadays, technology advances enable to streamline (optimize) internal- and external processes. Although the technology is already there the real estate transaction process is still very traditional – documents are decentralized stored in multiple formats and standards, which makes parties unable to properly define what they are actually selling and buying. Hence, due diligence and negotiation is a cumbersome process and involved parties face various risks. Although, the process is known as cumbersome, the incentive is too small for a single company to develop a tool as proposed in this research. For example, the development of a tool as proposed costs $1 million and X amount per building – in this situation the calculation is made quickly. From this budget many individual transaction can be executed. Therefore, a large organization or collaboration should taking on a leading role in the development of, at least, the blockchain infrastructure.

But, '*what is in it for banks?*'. Currently, banks are known as commonly trusted parties. One of their main goals is a stable financial system, which is a prerequisite for a healthy economy and a prosperous society. In order to contribute to financial stability, and thus to be an unmistakable part of such a system, banks themselves will have to be 'financially healthy'. This requires a sustainable, future-proof business model that finds a balance between profitability – necessary to maintain solvency, to finance investments in the future and to offer returns to shareholders and savers – and an acceptable risk profile.

New technology advances enable new business models. Currently, the transaction process of an office building is a cumbersome process with problems related to unstructured- , non-digital- , unstandardized data which results in lacking data quality. The proposed blockchain infrastructure improves the cumbersome transaction process where the bank can benefit from. Benefits for a bank – assuming that documents are standardized – are:

- More reliability: information in the network is validated by all parties and satisfy requirements. Based on this audit trail reliable reports can be generated, such as financing reports.
- Transparency: information shared between parties is the same.
- Efficiency: structured and standardized data can form the input for internal workflows and analyses (risk assessments).

Besides above mentioned benefits social benefits occur as well. If the reliability and transparency of information enhance, fraud in real estate financing will be reduced. In addition it is plausible that new ways of financing real estate can be developed on the base of the proposed infrastructure.

As defined in Section 3.2, tokenization of a real-world asset is the digital representation of a real-world product – a new concept based on blockchain technology. In practise it turns out that tokenization of real estate comprises its economic value (Section 3.2.3). Although, the economic value of an asset is obviously linked to its characteristics, empirical findings show that parties are not able to properly define these characteristics. It turns out that quality of obtained information is often lacking and information cannot be found or seemed to be intentionally left out. The proposed infrastructure enhances the way of structuring data and guarantees quality. In this way the quality of a real estate token will be enhanced as well. This parallels the situation when buying a share of a company on the stock market. The price of a share (economic value) is linked to its characteristics – which can be found in a (manually or digitally) validated annual report. The proposed infrastructure purposes the same. It provides (authorized) insight in the current state of an asset, which, in turn, provides – due its hash-based architecture – reliability in the transaction process. Reliability in financing real estate contributes to determining the risk profile for banks.

A collaboration between banks (SBR Nexus[10]) – ABN AMRO, ING and Rabobank – can take the lead in the development of the proposed infrastructure. The aim of SBR is standardizing documents within processes and provision of simplified reports. When implementing the proposed infrastructure in combination with standardized contract API's can be connected to various databases, whereby the system will be automated, which speedsup the process of financing propositions and reduce associated risks.

7.4 Summary

In the previous chapter a blockchain technology based database is proposed. This chapter visualizes the proposed solution based on a prototype and discusses the validity of the infrastructure. In this way, the fifth research question can be answered: '*What does an office transaction based on the proposed blockchain model look like?*'. After validation of the proposed model the final research can be answered as well, which read as follow: '*What could be the potential role of a bank in a blockchain based transaction?*'.

All parties would have to sign up to the model for it to be valuable. Therefore, the tool is pragmatically validated by multiple future users. Before validating the a back-end and initial front-end prototype are developed to clarify the proposed infrastructure . First, the back-end, also referred to as infrastructure, is outlined. The proposed cryptographic audit trail logs validation information in the blockchain, transaction information (Figure 51). Validated information is stored in the blockchain once the property is acquired. Based on this fundamental new documents can be add and revisions monitored. Essential information (framework) of each document in is validated and logged in the blockchain hence data input is structured and of high quality. One of the interviewees stated that data management is a core element for an ecosystem. In turn, parties could develop their own API's to analyze available data.

From a task perspective (BPMN model) the process their are limited changes. However, the data within the process is structured according to an index, validated by three parties and transparently shared. In the proposed model property owners are not able to withhold information, due to the cryptographic audit trail in combination with an authorization rule set. Furthermore, due to the high quality and transparency of data, due diligence time and risk assessments will be reduced, whereby the overall transaction process will be improved.

For the blockchain model to be deemed acceptable, this research makes use of pragmatic validation to ensure that the model resolves the identified pain points. During the validation the current situation is compared with the proposed situation by a property manager, head of investments,

[10]SBR is a collaboration between the Ministry of Economic Affairs, Ministry of the Interior and Kingdom Relations, Ministry of Justice and Security, tax authorities, the Camber of Commerce and the Central Bureau of Statistics. Furthermore, software companies are involved. Initiators of SBR Nexus are ABN AMRO, ING and Rabobank.

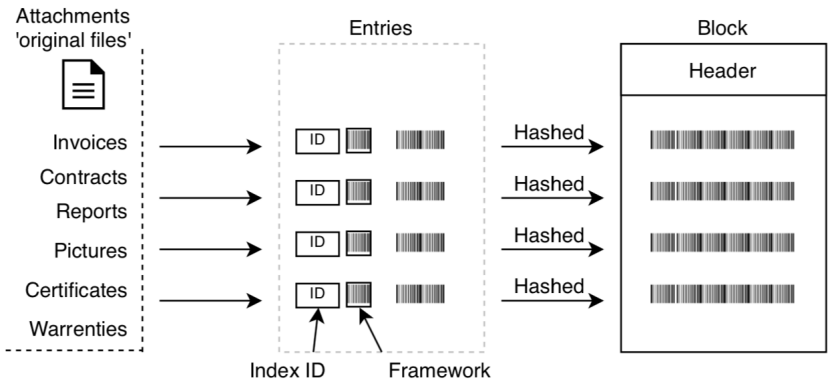

Figure 51: Hash infrastructure.

financial- and IT advisor and an enterprise architect. All interviewees indicate that the proposed model resolve the pain points and, in turn, improve the transaction process. Although from a technical perspective the model is interesting for future data management, challenges are related to the implementation of the model. Furthermore, current real estate data is not created or held in a standard format and everyone interviewed spoke about the enormous challenge faced by data standardization.

In line with the validation the role of a bank is extensively discussed. Although the process is known to be cumbersome, there is not a great enough incentive for one single party to develop a blockchain tool – all parties would have to sign up to use it for it to be valuable. Besides, all corporate parties could benefit from more reliability, transparency and efficiency. Hence, a collaboration between banks with a large market coverage would be best placed to take the lead in standardizing documents for financing real estate and, in turn, the development of a blockchain tool as proposed. In this way, banks will receive standard information, which they can use to optimize their own workflows (e.g. risk assessments). This succeeds only if all party are convenient of the applications' added value.

Chapter 8

Conclusion & Discussion

Although recent studies have examined the possibilities of applying blockchain technology, the specifics remain unclear. In this research, blockchain technology is proposed as a solution for the problem: how to improve the transaction process of an office building. In this final chapter, the conclusion of this research will be described and discussed. The conclusion and deriving discussion are based on the theoretical framework (Section 2 and 3), empirical findings (Section 5) and validation of the proposed blockchain model (Section 6 and 7). In addition to the conclusion, limitations of the research and recommendations for further research will be discussed.

8.1 Conclusion

In this research, blockchain technology is proposed as a solution for the problem: how to improve the transaction process of an office building. It aims to identify the challenges currently faced, and suggests how blockchain technology can solve them. By analyzing the current CRE transaction process and sketch out the fundamentals and current development of blockchain technology. This section is concerned with answering the main research question:

'How to implement blockchain technology to improve a real estate transaction of an office building?'

The main research question can be answered by means of addressing the established research questions of Section 1.

Research question 1 – Characteristics CRE transaction process
In order to explore the current way of working, characteristics (stakeholders, data streams, etc.) of a commercial real estate (CRE) transaction are determined. With the insights obtained in Chapter 2 the first research question is answered: '*What does a commercial real estate transaction and specific the transaction process of office buildings look like?*'.

Technology advances are changing markets world wide, including the CRE sector. CRE – commercial, industrial and logistics and residential real estate – is defined as tangible income producing assets of land and buildings, but refers to title ownership ('bundle' of rights) as well (Ling and Archer, 2012). Commercial real estate (CRE) transactions have always been collaborations involving multiple parties. Due to the markets' fundamental characteristics – heterogeneity and immobility – real estate transactions face the joint challenges of information inefficiencies and corresponding high transaction costs (Ling and Archer, 2012). The transaction process of an office building is divided into multiple stages (Crosby and McAllister, 2015; Dijkstra, 2017; Hordijk and Teuben, 2008; Just and Stapenhorst, 2018):

1. Preparation

2. Marketing and Pre-due diligence
3. Due diligence
4. Completion

Currently, due diligence phases and negotiations (completion) are carried out to verify and validate information. These processes are a key indicator of the lack of transparency and perceived unreliability of the data used in the transaction process. Furthermore, the decentralized way of working with various 'non-digitized' documents makes the process complex and unstructured. Implementing new technologies could lead to an improvement in the transaction of an office building in the future.

Research question 2 – Introduction to blockchain technology
Currently, blockchain is a buzz word, a hype, with an interesting underlying technology. To explore the potential of blockchain technology, a clear understanding of its general functioning and possibilities are given. Based on literature in Chapter 3 the second research question is answered: *'What is the status quo in regard to blockchain technology in real estate?'*. Blockchain is simply a new method of structuring and handling data – which is often sufficient but not often necessary. A blockchain distributed consists of five core elements (Hileman and Rauchs, 2017; Seuren, 2018; Swan, 2015; Tapscott and Tapscott, 2016; Tasca et al., 2017):

- Cryptography
- Peer-to-peer (P2P) network
- Validity rules
- Consensus mechanism
- Ledger

Blockchain and its deriving applications, e.g. smart contracts (Blockchain 2.0) and applications (Blockchain 3.0), could support and enhance the reliability, efficiency and security of data transferred among a network (Swan, 2015, p. ix). Therefore, blockchain technology features seem to provide a solution that could enhance the transaction of office buildings. Although early studies indicated that blockchain technology is theoretically applicable in the real estate sector, limited research has focused on the development of applications and so how to implement the technology remains unclear. Therefore, it is interesting to do a more in-depth review of how the implementation of a blockchain application could improve the current transaction process and be an 'enabler' for new business models.

Research question 3 – Identification of pain points
The insights derived in Chapter 2 form the input for a Business Process Model and Notation (BPMN) – 'The leading standard in the frame of business processes and workflow modeling languages' (Chinosi and Trombetta, 2012, p. 124). Based on this model – interviews were conducted to identify and map pain points to specific phases and tasks in the transaction process – the third research question is answered: *'What pain points occur during the transaction process of an office building?'*. Multiple interviews are conducted in order to verify the process and identify pain points. Although the process of transacting real estate is quite complex, saturation was reached after four interviews. All interviewees indicated that pain points mainly occur during due diligence and completion, and are related to *data structure* and *data quality*. Although, pain points occur during due diligence and completion, they are formed during the operation phase of a property. This makes sense as problems tend to arise when data is analyzed (due diligence), which is the input for negotiations in the completion phase. To gain more in-depth knowledge an extra interview is conducted with a property manager. From the interviews it can be concluded that pain points mainly are the consequence of the decentralized way of work during the operation phase. In this way documents are often not up-to-date and can easily be lost, and structure is lacking.

If we are to improve the transaction process, the proposed solution should resolve identified pain points and, as a result, streamline the transaction process of an office building.

Research question 4 – Assessing blockchain based model
By combining the theoretical framework and empirical findings (Section 2 and 3), Chapter 6 answers the fifth research question: '*What blockchain technology features could be used to enhance the current transaction process of an office building?*'. Firstly, to improve the current transaction process of an office building a model without blockchain technology is proposed – a centralized database. The centralized database is divided into four indexes: technical-, commercial-, financial- and legal index. These indexes consist all essential elements for doing a transaction (Property Markets Research Team, 2004). During the life cycle of a property, maintenance and adjustments can be logged in the proposed database by means of frameworks. Continuously updating maintenance and adjustment related files enable parties to define their property at any time compared with the 'original' files (when buying a property). Although working in a centralized way is helpful to overcome the pain points, challenges such as reliability, transparency and security of data arise. In contrast, blockchain is simply a new method of decentralized structuring and handling data.

Based on aforementioned pain points it could be assumed that a reliable audit trail of files could improve CRE transactions. Therefore, it is analyzed if blockchain technology could improve the process, and if so with what features. The structure and functionality of the proposed system is explained by means of a Merkle tree. The database is structured according to the data requirements of a transaction, which is split into two elements (indexes):

- physical (technical) elements
- contractual (commercial, legal and financial documents) elements

Grounded on this tree a cryptographic audit method is proposed. Physical and contractual data can be logged on a blockchain based on its consensus mechanism and cryptographic encrypting method, also referred to as cryptographic audit trail or hash chain. The proposed audit trail keeps track of, in a log file (class diagram framework), which adjustments are made towards the 'original' files. After validation by external nodes (oracles) these log files with adjustment related information are added to the database. The original files are stored on the servers of the involved parties and validation information (framework) is uploaded in the blockchain. The validated framework consists of all essential data elements of a file (e.g. index code, validation date etc.). By implementing this technology parties are able to monitor their property based on record-keeping. Validated record-keeping is the first step towards creating digital real estate transactions and resolving the pain points in the process.

Based on the described blockchain fundamentals it is assumed that the current process can benefit from blockchain technology. The structure and functionality of the proposed model are outlined by means of a Merkle tree. Consensus mechanism and encrypting model features ensure that pain points related to data structure and quality will be solved. Furthermore, a distributed ledger alter the way data is secured. The framework (class diagram) will serve as format, just like in the proposed centralized database. In the first place the system allows parties to define, in a structured and reliable way, what they are actually selling and buying on the basis of validated information. Although the proposed model digitizes and validates physical and contractual elements during the life cycle of a property, the system is not able to interact with other databases due to lack of standardization whereby oracles are needed for validation. In the future standardized documents could lead to an automatic record-keeping chain which enhances the process even more. All this could make the proposed application suitable for managing physical and contractual data, which, consequentially, could enhance the transaction process.

Research question 5 – Visualization and validation of proposed blockchain model
In order to validate the proposed blockchain model a prototype was developed. Based on this prototype and validation the fifth research question is answered: '*What does an office transaction based on the proposed blockchain model look like?*'.

For the blockchain model to be deemed acceptable, this research makes use of pragmatic validation to ensure that the model resolves the identified pain points. The proposed transaction process is visualized in Figure 52.

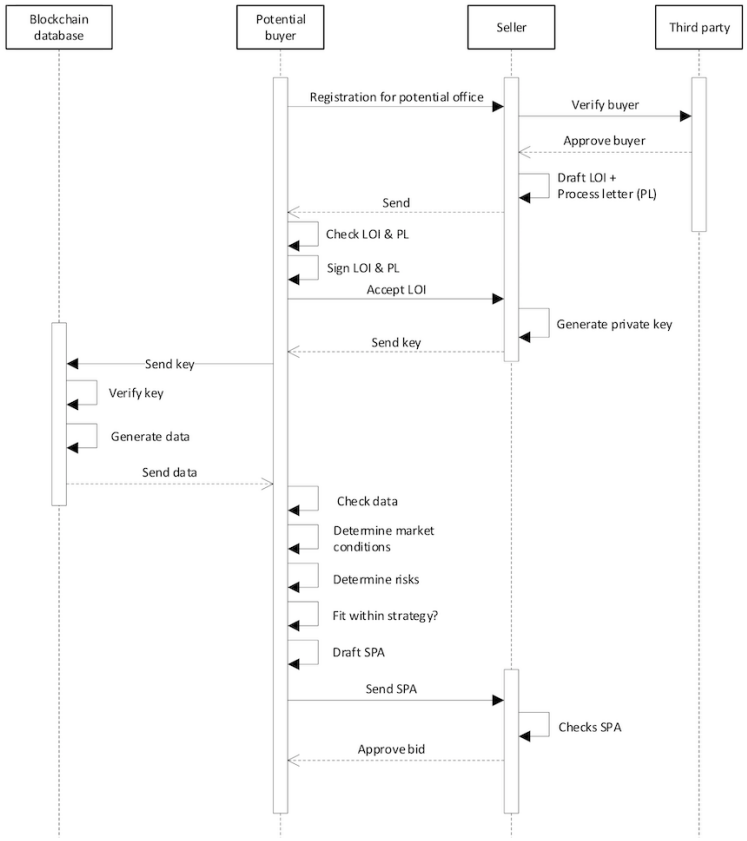

Figure 52: Example of a blockchain technology based office transaction.

In contrast to the current situation, validation information (framework) is stored in a shared blockchain database. By validating the framework, data input is validated and structure created. A property manager, for example, sees the added value of the tool to be in storing and sharing data without the need to interact with other parties. Other interviewees indicated that they would benefit from the increased transparency and therefore reliability in the process. These benefits occur due to the hashing structure (foundation of the proposed model). Hence, parties in the network can be authorized to view and read validated information and corresponding contracts or documents. For this reason all interviewees autonomous indicate the potential of the proposed application.

Research question 6 – Assessing the role of a bank
Currently, the mentioned pain points by all interviews are not big enough to solve by a single party. Therefor, Chapter 7 discusses the potential role of a bank, which answers the sixth research question: '*What could be the potential role of a bank in a blockchain based transaction?*. Chapter 7 describes SBR (Standard Business Reporting) Nexus – a collaboration of Dutch banks – as potential group who could take the lead in the development of the proposed tool. Banks are known as commonly trusted parties which are ideal to develop an independent blockchain database. However, to run a distributed database standardization of contracts and collaboration between multiple parties needed, whereby SBR Nexus could take the lead. In this way, involved parties, such as banks, will receive standard information, which they can use to optimize their own workflows (e.g. risk assessments).

Main research question – Assessing the implementation of blockchain technology
This design science research proposes a blockchain based infrastructure to improve the current transaction process of an office building. During validation of the application, all interviewees indicated that the application is an interesting first step towards a digital and more transparent ecosystem. The structure and quality of data – these are the main elements in a real estate transaction and so are essential if the process is to be streamlined – available will be enhanced by implementing the proposed blockchain infrastructure.

After answering all research questions, a well-founded answer on the main research question can be made.

> '*How to implement blockchain technology to improve a real estate transaction of an office building?*'

To start with, a theoretical framework outlines the transaction process of real estate and the status quo of blockchain technology. Although early studies indicated that blockchain technology is applicable in the real estate sector, limited research has focused on the development of applications and so how to implement the technology remains unclear. In line with earlier work, experts are asked to share their vision about CRE transactions and map pain points in the process. After designing the infrastructure of the blockchain model, the experts are asked again to pragmatically validate the proposed infrastructure. Using this method, it can be demonstrated that the developed infrastructure is promising and satisfies the expectations of future users.

Alongside the benefits of the proposed system, there are some challenges one of the most important will be standardization. How should various types of real estate data such as valuation reports, real estate collaterals, lease information etc. be connected. In order to provide a uniform recording of real estate data, consensus has to be reached on how to connect various aggregation levels (Kadaster, BAG, VHE, etc.) with each other. Moreover, the Real Estate Taxonomy has only recently gone live and has not yet been implemented in daily business of most organizations. The added-value of the system depends on it, but currently, the application could only be used to store and share 'original' files. If documents (e.g. contracts, inspection reports etc.) are standardized, then the validation of information could be automated by developing frameworks and connecting APIs. One could imagine that the implementation of the proposed application could be phased, starting with the standardization of one or two indexes, such as lease contracts or inspection reports. Lease contracts would be beneficial as they are an important means of determining the economic value of the property and are based on a fundamental document, called the ROZ-model. Therefore, standardization of lease contracts could be an easy and valuable starting point.

The proposed application improves the way specific asset are understood by structuring physical and contractual information in one place, and guarantees the quality of the data by using the blockchain mechanisms. Therefore, the tool is of immeasurable value for the future of real estate data management and the transaction process.

8.2 Limitations and recommendations for further research

This design science research proposes a blockchain audit trail that improves the transaction process of an office building. Although this research proposes a clear infrastructure for an application, various limitations and subjects for further research can be identified. This section elaborates both the limitations of the research as well as specific recommendations for further research.

8.2.1 Limitations of the research

The limitations of this research are inherent to the scope of this research. This research focuses on the transaction process of office buildings in the dutch real estate market. Although the proposed blockchain model enhances the current pain points and challenges of this process, this study has

limited dept. For example, due to the limited time of this thesis, there was chosen to interview (mainly) advisors within the real estate transaction process. Advisers are interviewed due to the involvement in various transaction processes, acting on behalf of the owner and their broad knowledge. Hence, a selective group of stakeholders in the transaction process is interviewed, which result in low external validity. To improve the external validity, more stakeholders could be interviewed to ensure that all roles are covered. Furthermore, a focus could be placed towards investors – the essential stakeholders in a transaction process.

In addition, research regarding *legal- and technical topics* are excluded form this research. Due to the limited knowledge of the author on these topics, these topics are left out of scope. For example, there are important European changes in data privacy regulation last year, called General Data Protection Regulation (GDPR). Currently, research regarding the effect of privacy regulation on the proposed application still remains. The same applies towards the *costs* of the development and implementation of the proposed tool. When drawing the balance between the current situation and a blockchain database, further research towards these topics is needed.

As with all new technologies, such as blockchain technology, most research focus on the applicability, limited research focuses on the development of an application. Although, this is not the first academic research that connects blockchain technology to real estate transactions, it is the first research that proposes a blockchain technology based application. However, due to the limited *practical use cases*, this research came up with various assumptions (e.g. technical and legal) how blockchain should be implemented. Hence, further research towards these assumptions is needed.

8.2.2 Recommendations for further research

Due to the explorative character of this design science research regarding blockchain technology, various recommendation for further research raise.

- This design science research proposes a first infrastructure to digitize physical and contractual data needed for the transaction process of an office building. The efficiency of the infrastructure mainly depends on standardization of document (e.g. contracts, inspection reports, etc.) In the near future, instead of using validating nodes (Oracles) to provide off-chain property information to the chain, the system can be extended with algorithms that validate and read data input. In order to automatically validate clauses and labels *standardization* of documents is needed. Therefore, exploring standardization and digitization of physical and contractual documents is considered as interesting. Research regarding these topic takes research regarding blockchain technology in real estate and development of blockchain applications a step further.

  "*Which building related documents can be standardized and what does this look like?*".

- During validation of the proposed application, interviewees indicate that physical data in office building is respectively stable – in sense of revisions to the 'original' situation. A property manager indicated that the proposed blockchain audit trail (record-keeping) could most valuable in managing residential real estate. Within *housing corporation* more physical and contractual revisions occur, hence the added value of a blockchain audit trail could be bigger. This could be an interesting field for further research.

  "*How could blockchain technology be implemented in managing physical and contractual information within housing corporations?*".

- Due to the immaturity of blockchain technology and limited knowledge of the author regarding legal related topics, *governmental regulation and legal aspects* are left out of scope. Research into the proposed blockchain technology application from a legal perspective would add benefits to implementation. In addition, this could lead to better adoption by many different organizations.

"*What legal challenges occur when implementing blockchain in the current real estate transaction process?*".

- Digitizing off-chain documents without standardized documents requires validating oracles. Oracles are independent third parties in the network who validate all physical and contractual data and add validated data to the blockchain (creating new blocks). Currently, validating oracles are not known as party within the real estate sector. Therefore, in-depth research should be conduct towards this new function.

  "*How should the function of validating oracles look like and how should they perform?*".

- Blockchain technology is an 'enabler' of new business models, by changing one or more 'building blocks' of the *Business Model Canvas*. Hence, research regarding the role of a bank is conducted. Future research can be conducted to the impact of a digital transactions (ecosystem) on current business models of real estate parties, such as a broker.

  "*What is the impact of a digital ecosystem for the business model of a broker?*".

8.3 Discussion

Parties in the Dutch CRE sector indicate the need for transparency. One of the interviewees even makes a comparison between shares of a company and a real estate portfolio, in sense of information transparency. Currently, due diligence phases and negotiations are carried out to verify and validate information. These processes are a key indicator of the lack of transparency and perceived unreliability of the data used in the transaction process.Furthermore, the decentralized way of working with various 'non-digitized' documents makes the process complex and unstructured.

Scoping on the transaction of an office building and its additional issues, the research proposes a distributed database by means of blockchain technology. Although recent studies have examined the possibilities of applying blockchain technology, the specifics (applications) remain unclear. For example, researches of Dijkstra (2017) and Veuger (2017) mainly focus on the theoretical applicability of blockchain technology in the CRE sector. Additionally, Seuren (2018) did a more in-depth research towards the applicability of blockchain technology in real estate due diligence by means of proposing an applicability scheme. All studies indicate that blockchain technology could lead to improvements in efficiency, transparency and therefore trust.

In contrast to the aforementioned studies, this research proposes an infrastructure for a blockchain-based application to improve the current way real estate is transacted. In the first place the proposed model can be deployed as record-keeping tool (blockchain audit-trail). Physical and contractual information, related to a property, is recorded and validated by means of blockchain features during the life cycle of a property (operation phase). Validation related information is summarized in a framework, which is encrypted (hashed) and stored in the blockchain. In this way, parties are able to monitor what physical and contractual activities have been executed compared to the original stored files. During verification of the proposed model all interviewees indicate that the tool can serve as solution for the mentioned major pain points, and thus enhance the current transaction process. Validated record-keeping is the first step towards creating digital real estate transactions and resolving the pain points in the process. Although, blockchain technology is what builds digital records of physical and contractual information, it does also come with challenges. These are as a result of the immaturity of the technology, a lack of standardization and limited examples of successful application. Hence the implementation of the proposed model is quite complex. Currently, the correctness of documents need to be validated by validating nodes (oracles) in the network, due to the lack of standardization. For the system to add value, data such as reports and inspection frameworks must be standardized. If this is possible, the record-keeping application could be linked to external databases (sources) by way of an API. Therefore, data could be automatically validated without the need for oracles, and analyzed by the user. Also,

authorization rules in the network could be much more detailed (e.g. data such as contract clauses could be recorded).

Although, the proposed record-keeping blockchain database is helpful to overcome the pain points and challenges, the tool could streamline the process much more by standardization of documents in the future. In line with future possibilities Chapter 3 described blockchain tokens (tokenization) as new concept within the blockchain technology. Tokenization is defined as a digital representation of an object. From literature it can assumed that various organizations tokenize real estate. In practice tokenization of real estate is the digital representation of the objects economic value and its ownership. This research proposes a first application towards a digital representation of an object in the sense of physical and contractual information. Hence, data in the blockchain database can serve as foundation of a blockchain token. In order to clarify the practical applicability of the proposed blockchain ecosystem an example within the stock market is given. Once, a potential buyer show interest in a specific stock the buyer will read the validated annual reports of the company. Currently, property owners are not able to define what they are actual selling. The proposed tool improves the way of defining the specific asset by structuring physical and contractual information and guarantee quality by its mechanisms.

A validated digital representation of an office building, also referred to as *digital building passport*, streamlines the transaction process due to the increase of transparency and thereby reliability. It could be assumed that this improvement can lead to reduction in costs and a higher demand for real estate investments. Investing in real estate becomes much more easy due to the insight in validated information, just like shares of a company and its validated annual reports, as discussed before.

Although, technology advances, such as blockchain enable streamlining processes, neither companies or institutions are taking the lead to develop such a infrastructure to change a ecosystem. Although the process is sector wide known to be cumbersome, there is not a great enough incentive for one single party to develop a blockchain infrastructure – all parties would have to sign up to use it for it to be valuable. Therefore, a collaboration of organizations or institutions with a broad market coverage would be best placed to take the lead in standardizing documents for financing real estate and, in turn, the development of a blockchain infrastructure as proposed. Furthermore, an ecosystem will not be changed in one day. During the life cycle of a property a large amount of unique documents should be stored. One could imagine that the implementation of the proposed application could be phased, starting with the standardization of one or two indexes, such as lease contracts or inspection reports. Lease contracts would be beneficial as they are an important means of determining the economic value of the property and are based on a fundamental document, called the ROZ-model. Therefore, standardization of lease contracts could be an easy and valuable starting point.

All in all, the proposed application improves the way specific asset are understood by structuring physical and contractual information in one place, and guarantees the quality of the data by using the blockchain mechanisms. Therefore, the tool is of immeasurable value for the future of real estate data management and the transaction process.

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Appendix A

Information flow

1. Marketing material
1.1 Brochure or particulars
1.2 Site plan
1.3 Floor plans (and independent measured areas)
1.4 Verified tenancy schedule

2. Legal title and searches
2.1 Land Registry (Cadastral Data)
2.2 Relevant title documents
2.3 Lease agreements, including tenant information (BAG-data, CoC-data, Credit Ratings)
2.4 Third party consents
2.5 Defective title insurance policies
2.6 Searches
2.7 Any consents/authorities needed for transaction

3. Management information
3.1 Managing agents' contact details
3.2 Copies of most recent rent and service charge demands
3.3 Payment history and confirmation of status where consistent late payment
3.4 Arrears schedule and confirmation of status of all arrears
3.5 Service charge:
- 3.5.1 Current year's budget
- 3.5.2 Current year's apportionment (showing percentage and areas)
- 3.5.3 Full details of caps and fixed service charge, RPI uplift calculations
- 3.5.4 Last 3 years' service charge accounts
- 3.5.5 'Reserve Fund' statement – and confirmation if it is allocated
- 3.5.6 Expenditure to date
- 3.5.7 Service charge collected to date
- 3.5.8 Details of major service charge expenditure in the last 3 years and any anticipated expenditure

3.6 Insurance certificates
3.7 Last insurance valuation
3.8 Insurance claims history and details of any outstanding claims
3.9 Details of any disputes
3.10 Ongoing management transactions
3.11 Schedule of maintenance/service contracts (including notice periods)

4. Design and construction
4.1 Building contract and all appendices/specifications
4.2 Consultant details and professional appointments
4.3 Warranties/guarantees/bonds
4.4 Status of contractor/consultants
4.5 Details of consultants' professional indemnity insurance
4.6 Practical completion/making good defects certificates
4.7 Health and safety file
4.8 Operation and maintenance manuals
4.9 BIM information
4.10 Payments (retention) outstanding

5. Utilities
5.1 Supply contracts
5.2 Energy certificates / EPC calculations

6. Planning/statutory agreements/infrastructure
6.1 Copies of:
- 6.1.1 planning applications
- 6.1.2 planning permissions
- 6.1.3 approval of reserved matters/conditions
- 6.1.4 satisfaction of planning conditions

6.2 Confirmation of established use and certificate where relevant
6.3 Any planning agreements

7. Physical condition/environmental
7.1 Asbestos survey/assessment
7.2 Measured/structural/mechanical and electrical surveys
7.3 Environmental report
7.4 Environmental licences/notices
7.5 Energy Performance Certificate

8. Rates/outgoings
8.1 Rating assessments and valuation report
8.2 Any correspondence/appeals

9. Tax/financial
9.1 Any capital allowance elections
9.2 VAT details
9.3 Copy of option to tax and acknowledgement
9.4 WOZ-value
9.5 Any security and arrangements for discharge

Figure 53: Information checklist office building transaction. Source: (Dijkstra, 2017, p. 54)

Appendix B

Interview protocols

B.1 Interview protocol 1

Doel van het interview: identificatie en analyse van problemen in het huidige transactie proces van een kantoorgebouw.

Lengte interview 15 – 30 minuten

Datum & tijd:
Naam respondent:
Bedrijf:
Afdeling & titel:

Introductie interview methodiek en onderwerp
Allereerst, wil ik u bedanken voor uw medewerking aan dit onderzoek. Ik doe onderzoek naar de implementatie van blockchain technologie in het transactie proces van een kantoorgebouw. Met dit onderzoek beantwoord ik de volgende hoofdvraag: 'How to implement blockchain technology to improve the transaction process of an office building?'.

Om deze hoofdvraag te beantwoorden heb ik onderzoek gedaan naar het huidige transactie proces van een kantoorgebouw en de status quo met betrekking tot blockchain technology. Hieruit komt naar voren dat het huidige transactie proces kan worden opgedeeld in vier stappen, vanuit verkopers oogpunt: Preparation, Marketing, Due-diligence en Completion. Echter, wordt gedurende de marketing ook een pre-due diligence uitgevoerd door de potentiële koper. De verschillende stappen in combinatie met de overdracht van informatie tussen betrokken partijen hebben geresulteerd in een proces map (BPMN).

Het BPMN model globaal doornemen

Blockchain wordt op dit moment gezien als een oplossing opzoek naar een probleem. Het doel van dit onderzoek en interview is echter om blockchain een oplossing te laten zijn voor een probleem. Door middel van dit interview probeer ik inzicht te krijgen in de problemen die zich voor doen gedurende het transactie proces. Met mijn opgedane blockchain technologie kennis zal ik tot oplossingen komen voor de geïdentificeerde problemen. Graag zou ik deze oplossingen in een tweede interview met u door willen nemen.

De interview methodiek die gebruikt wordt is semi-gestructureerd, dit houdt in dat elk vraag uitvoerig beantwoord kan worden en dat de interviewer door kan vragen. Gedurende het interview wordt het vooraf doorgenomen BPMN model als uitgangspunt genomen.

De informatie die verzameld wordt tijdens het interview zal alleen gebruikt worden voor dit onderzoek en ten alle tijden anoniem en vertrouwelijk zijn. Heeft u nog vragen of heeft u meer informatie nodig? Als u geen vragen meer heeft start ik het interview.

Interview vragen – Algemeen

1. Kunt u kort uw loopbaan beschrijven?
2. Wat is uw rol in het transactie proces van een kantoorgebouw?

Interview vragen – Identificatie problemen

1. Kunt u beknopt de problemen omschrijven die u ervaart\ziet gedurende het proces?
   (a) BPMN model laten zien.
   (b) Kunt u aangeven in de proces map waar u precies deze problemen ervaart?
2. Waardoor worden deze problemen veroorzaakt?
3. Welke personen zijn betrokken bij de betreffende problemen?
   (a) Welke personen spelen een specifieke rol?
4. Wat verstaat u onder de genoemde problemen (tijdsverlies, oplopende kosten of verhoogd risico op fouten)?
5. Hoe vaak komt dit probleem voor?
6. Kunt u de verschillende problemen een cijfer geven?

Interview vragen – Transactie proces

1. In welke fase vindt volgens u het meeste oponthoudt plaats? Kunt u de fases (preparation, marketing, pre-due diligence, due diligence & completion) nummeren van 1 t\m 5?
2. Hoe zou het ideale process er volgens u uitzien (als u het opnieuw zou mogen inrichten)?

Nogmaals, bedankt voor uw deelname aan het interview. Ik ben er van overtuigd dat ik deze informatie kan gebruiken voor mijn onderzoek. Heeft u verder nog aanvullingen of opmerkingen op het interview? Als er nog elementen zijn die ik ben vergeten te behandelen, schroom niet om achteraf contact op te nemen. Als er geen vragen meer zijn dan beeindig ik nu het interview.

B.2 Interview protocol 2

Doel van het interview: analyse van de operation phase van een kantoorgebouw.

Naar aanleiding van de uitkomsten van het onderzoek naar de problemen in het transactie proces is er onderzoek gedaan naar het property management proces en de daarin voorkomende problemen. Bij het onderzoeken van het property management proces is er gebruik gemaakt van de volgende semi-gestructureerde interview vragen.

Interview vragen – Algemeen

1. Kunt u kort uw loopbaan beschrijven?
2. Wat is uw rol in het transactie proces van een kantoorgebouw?

Interview vragen – Identificatie problemen property manager

1. Welke stappen onderneemt u wanneer u een wijziging doorvoert in een van de panden?

2. Welke stappen onderneemt u wanneer u een klacht binnen krijgt?
3. Welke problemen komt u tegen in het huidige werk als property manager?
4. Wanneer wordt een property manager betrokken in het verkoopproces (begin, eind, helemaal niet), en wanneer zou hij/zij betrokken willen worden?
5. Welke problemen komt u tegen in het huidige proces, wanneer er informatie wordt opgevraagd voor het verkopen van een pand?

B.3 Interview protocol 3

Doel van het interview is het pragmatisch valideren van de voorgestelde blockchain applicatie.

Om het voorgestelde model te valideren zijn de geïnterviewden van ronde 1 gevraagd om hun mening te geven. Dit is eveneens gedaan aan de hand van semi-gestructureerde interviews.

Interview vragen – Validatie

1. Wat is uw eerste reactie op het blockchain model die als oplossing wordt voorgesteld?
2. Zou u deze tool willen gebruiken?
3. Wat zijn de grootste uitdagingen denkt u bij het implementeren van zo'n tool?
4. Hoe ziet u het ideale proces dan voor u?

Appendix C

Transcripts interviews

Confidential

For the full version of the Appendix, please contact the author.

Appendix D

Transaction process – BPMN

This chapter elaborates the BPMN model that visualizes the current transaction process of an office building and extensively discuss all related tasks.

D.1 Preparation

During the preparation phase all documents will be assembled of the specific asset. At the end of the preparation phase the seller is able to send asset specific marketing information (e.g IM, rent rolls, CAPEX, etc.) from a data room to potential buyers with accompanying NDA and process letter.

Table 2: In-dept information preparation phase

Involved actor(s)	Seller (investor) Sellers broker
Tasks in BPMN model	1. Gather all existing relevant data *(By: Seller)* 2. Discuss intern the need of a broker *(By: Seller)* 3. Draft investment memorandum (IM) *(By: Seller)* 4. Draft non-disclosure agreement (NDA) *(By: Seller)* 5. Draft process letter *(By: Seller)* 6. Draft investment memorandum (IM) *(By: Sellers broker)* 7. Draft non-disclosure agreement (NDA) *(By: Sellers broker)* 8. Draft process letter *(By: Sellers broker)* 9. Setting up marketing strategy *(By: Sellers broker)* 10. Determine marketing strategy *(By: Seller)* 11. Confirmation of preliminary data *(By: Seller)* 12. Preparing the data room *(By: Sellers broker)*

BPMN tasks

The first step, after the owner of an office building decided to sell the asset, is gather all relevant data (e.g. general market overview & asset aspects, technical quality (CAPEX), analysis of current & expected rent, etc.) of the asset by the current owner, called seller. The obtained information of the specific asset is summarized in an IM. Furthermore, a NDA and process letter are drafted to secure and describe the transaction process. The seller can perform the tasks of preparing a IM, NDA, process letter and marketing strategy themselves or contract third parties to do it (sellers broker). In case of the involvement of a third party, the seller receive the document from the third party and define a marketing strategy. Finally, the obtained information will be

confirmed by the seller and a data room – including all gathered information – will be set up by the sellers broker. The following data elements are complete and form the basis for the next phase with the accompanying NDA and process letter: Investment memorandum including asset specific information, a rent roll (e.g. MS Excel format, a list of expected CAPEX (e.g. MS Excel format).

D.2 Marketing

As discussed in Section 2.2.2 the marketing phase can be distinguished from a seller- and buyers perspective. In this phase the seller is generating a longlist of investors that are interested in buying the asset. The investors receive preliminary information by signing a NDA. Due to checks by the potential buyer a Head of Terms will be drafted – including initial bid – and negotiated with the seller. Finally, a shortlist (e.g. three potential buyers) will be created for the due-diligence phase. During the marketing phase from both sellers are buyers point of view assumptions are made. First, from a sellers point of view it is optional to call in an external advisor – sellers broker. In this research a sellers broker is involved to guiding the bidding process. Furthermore, in particular larger companies, have the capacity to do a pre-due diligence by themselves. However, during this research the assumption is be made that brokers and external advisors provide assumptions related to possible risks (red flag assessment).

BPMN tasks

Due to the involvement of different stakeholders the tasks obtained form the BPMN model are split into two different tables (Table 3 and 4): marketing for sellers point of view and pre-DD from buyers point of view.

Table 3: In-dept information marketing

Involved actor(s)	Seller (investor) Sellers broker
Tasks in BPMN model	14. Generation of candidate list *(By: Sellers broker)* 15. Preliminary data & NDA *(By: Sellers broker)* 35. Collect Head of Terms candidates *(By: Sellers broker)* 36. Send collected Head of Terms *(By: Sellers broker)* 37. Check Head of Terms *(By: Seller)* 38. Receive information bid selection *(By: Sellers broker)* 39. Contact bidders *(By: Sellers broker)* 39. Sign Head of Terms *(By: Seller)* 40. Open data room *(By: Sellers broker)*

From a seller point of view (Table 3) the marketing phase start with generating a list of potential candidates (buyers). Once, a list of potential candidates (known as 'longlist') a non-disclosure agreement is signed and the preliminary data send – investment memorandum including rent rolls and CAPEX. The potential candidates analyse the preliminary data and draft a Head of Terms (Table 4). The Head of Terms of the potential are collected and send to the seller. Once, the received head of terms are analyzed by the seller and a shortlist of potential buyers is formed. The negotiation between the seller and buyer party regarding the drafted head of terms can result in changing the initial bid or refrain from the deal.

From a buyers point of view the marketing phase is better known as pre-due diligence phase (Table 4). The buyer will do an more in-dept research regarding the available information. The pre-due diligence phase start when the buyer found an office based on buyers determined conditions. Once, the buyer show interest for the specific office the buyer will be add to the longlist – generated by the

Table 4: In-dept information pre-due diligence

Involved actor(s)	Buyer (investor) Buyers broker Appraiser Advisers Funder
Tasks in BPMN model	13. Register for available office *(By: Buyer)* 16. Sign NDA *(By: Buyer)* 17. Check data for completeness *(By: Buyer)* 18. Call in advisors or broker *(By: Buyer)* 19. Request all information *(By: Buyers broker)* 20. Draft assumptions *(By: Buyers broker)* 21. Receive all information *(By: Appraiser and Technical advisor)* 22. Analyse information for taxation assumptions *(By: Appraiser)* 23. Taxation assumption report *(By: Appraiser)* 24. Analyse technical information *(By: Technical advisor)* 25. Technical assumptions report *(By: Technical advisor)* 26. Collect all relevant data (public data) *(By: Buyers broker)* 27. Determine possible red flags *(By: Buyers broker)* 28. Draft Head of Terms *(By: Buyers broker)* 29. Request financial approval *(By: Buyer)* 30. Analyse financial information *(By: Funder)* 31. Financial approval *(By: Funder)* 32. Receive financial approval *(By: Buyer)* 33. Fit within strategy and portfolio *(By: Buyer)* 34. Draft Head of Terms *(By: Buyer)* 41. Receive signed Head of Terms *(By: Buyer)*

seller. The candidates on the longlist receive, after signing a non-disclosure agreement, preliminary information (e.g. IM, rent rolls, CAPEX etc.). First the received preliminary information needs to be checked for completeness and risks (red flag assumptions). It is assumed that the red flag assumptions will be determined by external advisors such as appraisers, technical advisors and funders. The drafted red flag assumptions ,commissioned by the buyers broker, in combination with public information result in a red flag report of the buyers broker. This report discuss all the risks associated with the purchase of the asset. The red flag report in combination with the preliminary data form the input for the head of terms. During the pre-due diligence check of the buyers broker, it is assumed that the buyer itself does a financial check. The brokers red flag report, head of terms and buyers financial approval form the input for the discussion fit withing the strategy and portfolio direction of the buyer.

Once, the buyer decide that the property acquisition fit within the strategy of the portfolio/ company the buyer draft a final head of terms. If not, the buyer refrain from the deal or acquisition. The non-binding head of terms consists of the initial bid and main issues (Section 2.2.2). The final head of terms are collected by the sellers broker and send to the seller. The seller will select a buyer based on the head of terms which result in a shortlist. However, during this phase there is room for negotiations. The seller analyses the received head of terms and make comments. Based on the comments the buyer reviews the fit within the buyers strategy. Once, the buyer decide that the property acquisition fit within the strategy of the portfolio, respecting the comments of the buyer. The buyer adjust the previous head of terms. This is a continuous process. Once the buyer receive the signed head of terms, the sellers broker open the data room and the due-diligence phases start.

D.3 Due Diligence

Buyers DD is the process of checking all the relevant available information before the purchase is actually made. The due diligence phase starts with opening the data room for all involved parties by the seller or sellers broker and ends by drafting a sales and purchase agreement. The red flag reports, drafted during the DD, form the input for the negotiation regarding the SPA.

Table 5: In-dept information due diligence

Involved actor(s)	Seller Buyer Appraiser Technical advisor legal advisor
Tasks in BPMN model	45. Open data room *(By: Seller)* 46. Receive a message of opening data room 47. Instruct advisors: data room is open 48. Taxation report 49. Determine red flags 50. Technical inspection 51. Determine red flags 52. Legal assessment 53. Determine legal red flags 54. Receive red flag reports 55. Draft general red flag report 56. Red flag meeting negotiation (buyer) 57. Red flag meeting negotiation (seller)

BPMN tasks

The pre-due diligence starts with opening the data room for all involved parties by the seller or sellers broker. In this research it is assumed that the sellers broker instruct the buyer of the accessible data room. Once the data room is accessible for the buyer, the advisors (e.g. appraiser, technical- and legal advisors) are instructed by the buyer to determine potential red flags. The taxation report, technical inspection & report and legal report form the input for the corresponding red flags. The formalized red flag reports by the advisors are bundeld by the buyer which result in a general red flag report. A red flag report include an identification of any substantial risk in regard to the specific asset.

D.4 Completion

The final phase of a commercial transaction is the completion phase: final bidding negotiation and closing the deal (delivery). After the red flag negotiation a mark-up version of the SPA is drafted including additional guarantees. This SPA is confirmed by both parties and ownership transferred by notarized deed.

BPMN tasks

After determining the red flags during the due diligence phase, the negotiating about the SPA start. The negotiation of the red flag report can result in refrain of the buyer from the deal, because the risk increases due to red flags. Furthermore, the specific red flags could also be priced in the head of terms. Depending on the negotiation results between the seller and buyer, the buyer

Table 6: In-dept information completion phase

Involved actor(s)	Seller Buyer
Tasks in BPMN model	58. contact buyer after red flag assessment 59. Draft SPA incl. final bid 60. Final SPA 61. Negotiate about final SPA 62. Checking SPA conditions 63. Notarization of final SPA 64. Sign final SPA (seller) 65. Sign final SPA (buyer) Close transaction

get internal board approval for the acquisition. The drafted SPA by both parties and additional guarantees (promises) are determined.

The red flags and head of terms are used as input for the sale and purchase agreement (SPA). Mostly based on the red flags the initial purchasing price formalized in the head of terms is adjusted. The SPA draft is negotiated and a final bid formed in the mark-up version of the SPA. The mark-up version of the SPA is stored in the data room by the seller. The SPA is only valid if it has been notarized and executed by notarial deed, which must include the entire SPA with all ancillary agreements. Hence, a notary is involved in this phase. After executing by notarial deed the transaction process is closed.

D.5 BPMN model

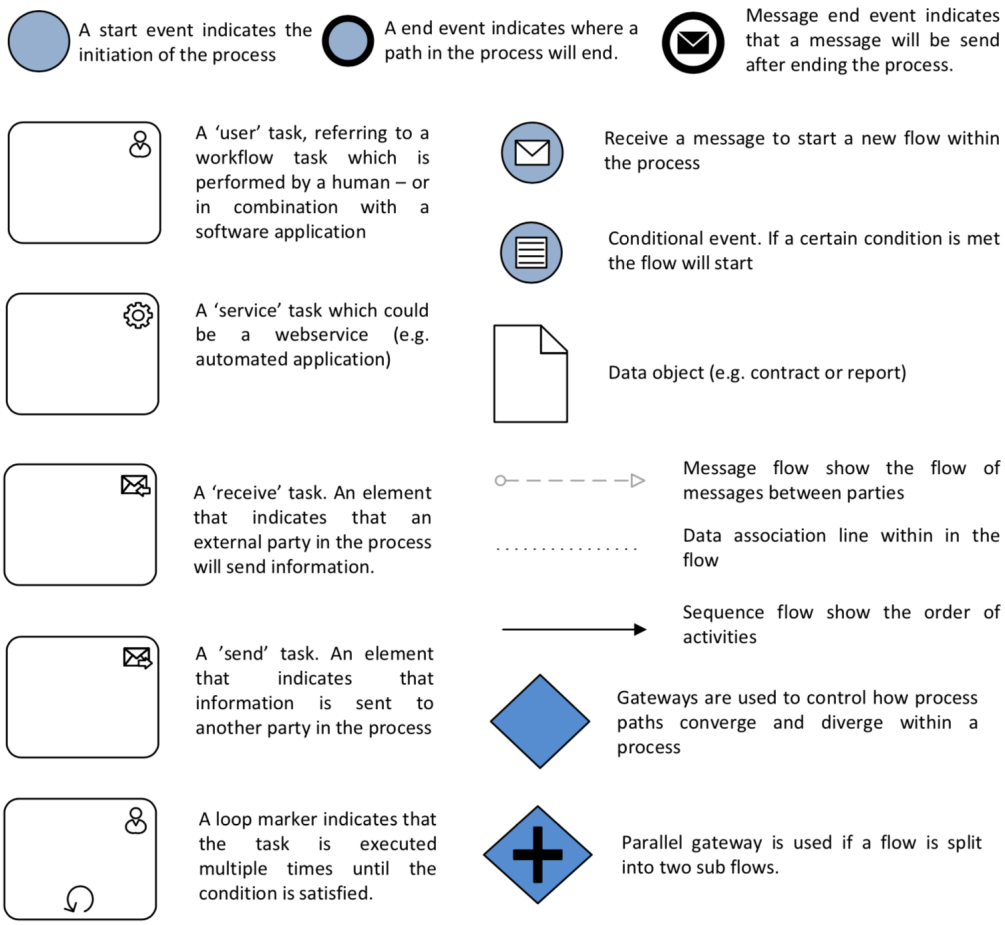
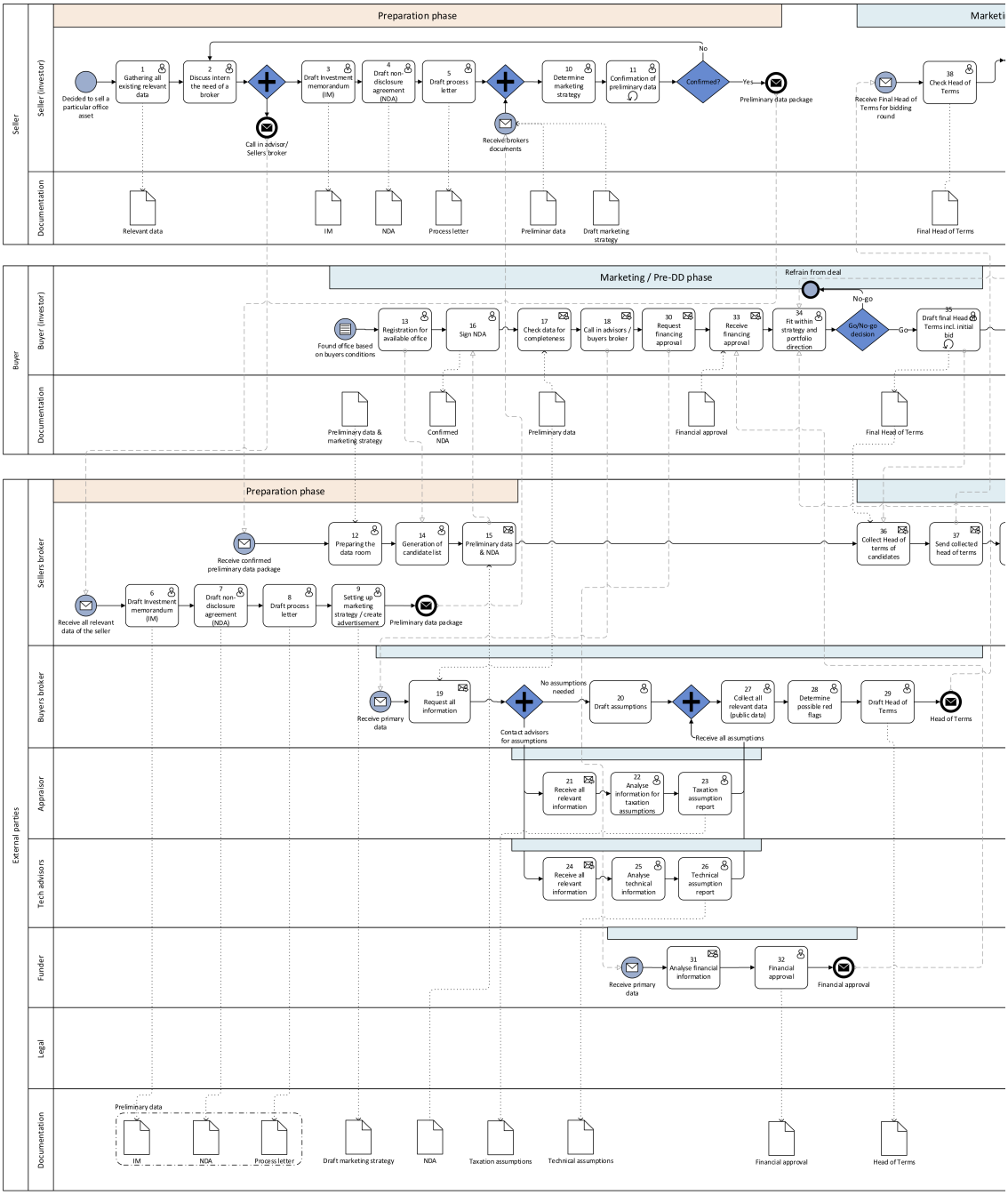
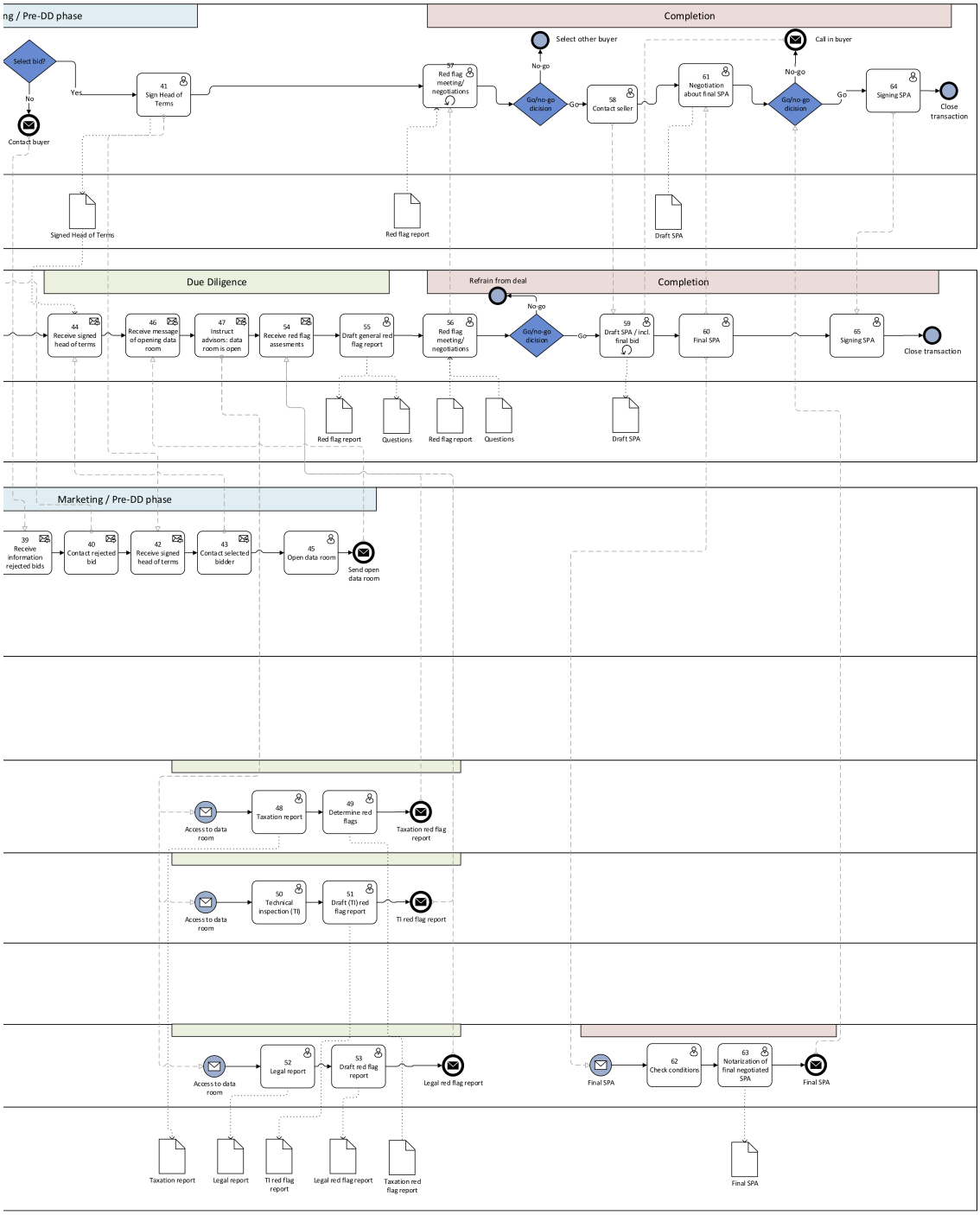


Figure 54: BPMN model legend


Seller
Seller (investor)
Documentation
Preparation phase
Decided to sell a particular office asset
1 Gathering all existing relevant data
2 Discuss intern the need of a broker
Call in advisor/ Sellers broker
3 Draft Investment memorandum (IM)
4 Draft non-disclosure agreement (NDA)
5 Draft process letter
Receive brokers documents
10 Determine marketing strategy
11 Confirmation of preliminary data
Confirmed?
No
Yes
Preliminary data package
Receive Final Head of Terms for bidding round
38 Check Head of Terms
Relevant data
IM
NDA
Process letter
Preliminar data
Draft marketing strategy
Final Head of Terms
Buyer
Buyer (investor)
Documentation
Marketing / Pre-DD phase
Refrain from deal
No-go
Found office based on buyers conditions
13 Registration for available office
16 Sign NDA
17 Check data for completeness
18 Call in advisors / buyers broker
30 Request financing approval
33 Receive financing approval
34 Fit within strategy and portfolio direction
Go/No-go decision
Go
35 Draft final Head of Terms incl. initial bid
Preliminary data & marketing strategy
Confirmed NDA
Preliminary data
Financial approval
Final Head of Terms
External parties
Sellers broker
Buyers broker
Appraisor
Tech advisors
Funder
Legal
Documentation
Preparation phase
Receive confirmed preliminary data package
12 Preparing the data room
14 Generation of candidate list
15 Preliminary data & NDA
36 Collect Head of terms of candidates
37 Send collected head of terms
Receive all relevant data of the seller
6 Draft Investment memorandum (IM)
7 Draft non-disclosure agreement (NDA)
8 Draft process letter
9 Setting up marketing strategy / create advertisement
Preliminary data package
Receive primary data
19 Request all information
Contact advisors for assumptions
No assumptions needed
20 Draft assumptions
Receive all assumptions
27 Collect all relevant data (public data)
28 Determine possible red flags
29 Draft Head of Terms
Head of Terms
21 Receive all relevant information
22 Analyse information for taxation assumptions
23 Taxation assumption report
24 Receive all relevant information
25 Analyse technical information
26 Technical assumption report
Receive primary data
31 Analyse financial information
32 Financial approval
Financial approval
Preliminary data
IM
NDA
Process letter
Draft marketing strategy
NDA
Taxation assumptions
Technical assumptions
Financial approval
Head of Terms


ng / Pre-DD phase
Completion
Select bid?
No
Yes
Contact buyer
41 Sign Head of Terms
Signed Head of Terms
37 Red flag meeting/ negotiations
Red flag report
Select other buyer
No-go
Go/no-go dicision
Go
58 Contact seller
Draft SPA
61 Negotiation about final SPA
Call in buyer
No-go
Go/no-go dicision
Go
64 Signing SPA
Close transaction
Due Diligence
Refrain from deal
Completion
No-go
44 Receive signed head of terms
46 Receive message of opening data room
47 Instruct advisors: data room is open
54 Receive red flag assesments
55 Draft general red flag report
56 Red flag meeting/ negotiations
Go/no-go dicision
Go
59 Draft SPA / incl. final bid
60 Final SPA
65 Signing SPA
Close transaction
Red flag report
Questions
Red flag report
Questions
Draft SPA
Marketing / Pre-DD phase
39 Receive information rejected bids
40 Contact rejected bid
42 Receive signed head of terms
43 Contact selected bidder
45 Open data room
Send open data room
Access to data room
48 Taxation report
49 Determine red flags
Taxation red flag report
Access to data room
50 Technical inspection (TI)
51 Draft (TI) red flag report
TI red flag report
Access to data room
52 Legal report
53 Draft red flag report
Legal red flag report
Final SPA
62 Check conditions
63 Notarization of final negotiated SPA
Final SPA
Taxation report
Legal report
TI red flag report
Legal red flag report
Taxation red flag report
Final SPA

Appendix E

Property manager activities

Property management activities according to Driel van (2010) (Dutch).

Commercieel / Administratief

- Promotie van objecten in de markt
- Werven van potentiele huurders
- Screenen van de huurder
- Administreren van:
  - Verhuurovereenkomst
  - Huurwaarborg
  - Sleutel overdracht
  - Beschrijving staat van het gehuurde
  - Huurbetalingen en indexeringen
- Coördineren betalingsherinnering en evt afhandeling incasso-traject
- Coördineren en administratie 'servicekosten-leveringen'
- Coördineren en administratie reparatieverzoeken en klein onderhoud
- Informatie-uitwisseling met eigenaren / taxateurs / adviseurs

Technisch

- Coördineren en administratie 'servicekosten-leveringen'
- Coördineren en administratie reparatieverzoeken en klein onderhoud
- Contracteren onderhouds- en serviceleveranciers
- Wettelijke keuringen
- Opstellen en uitvoeren MJOP
- Begeleiden kleine ad-hoc verbouwingen
- Controles / eigen inspecties ter plaatse
- Afstemming en communicatie met huurders en verhuurder inzake onderhoudswerkzaamheden
- Administratie en facturatie

Appendix F

Database input

1. Technical index

1.1 Site plan (PE)

1.2 Floor plan (PE)

1.3 Arreas schedule and confirmation of status of all arrears (PE)

1.4 Building contract and all appendices/ specifications (CE)

1.5 Consultant details and professional appointments (CE)

1.6 Warranties and guarantees (CE)

1.7 Status of contractor/consultants (CE)

1.8 Details of consultants' professional indemnity insurance (CE)

1.9 Practical completion/making good defects certificates (PE)

1.10 Health and safety file (PE)

1.11 Operation and maintenance manuals (PE)

1.12 Construction information (PE)

1.13 Supply contracts (CE)

1.14 Energy certificates/EPC calculations (CE)

1.15 Asbestos assessment (PE)

1.16 Environment report (CE)

1.17 Environmental licences/notice (CE)

1.18 Energy Performance Certificate (CE)

2 Commercial index

2.1 Tenancy schedule (CE)

2.2 Rental agreements, including tenant information (BAG-data, Coc-data, Credit Ratings) (CE)

2.3 Managing agents' contract details (CE)

2.4 Copies of most recent rent and service charge demands (CE)

2.5 Payment history and confirmation of status where consistent late payment (CE)

2.6 Service charges (CE)

2.7 Insurance certificates/valuation/claim history/details of any disputes (CE)

2.8 Ongoing management transactions (CE)

2.9 Rating assessments and valuation report (CE)

3 Financial and Legal index

3.1 Land registry (Cadastral data) (CE)

3.2 Title documents (CE)

3.4 Third party consents (CE)

3.5 Title insurance policies (CE)

3.6 Searches (CE)

3.7 Any consents/authorities needed for transaction (CE)

3.8 Outstanding payments (CE)

3.9 Any capital allowance elections (CE)

3.10 VAT details (CE)

3.11 Copy of option to tax and acknowledgement (CE)

3.12 WOZ-value (CE)

3.13 Any security and arrangements for discharge (CE)

(PE) = Physical element
(CE) = Contractual element

Appendix G

Standard rental agreement - ROZ-model

MODEL HUUROVEREENKOMST KANTOORRUIMTE
en andere bedrijfsruimte in de zin van artikel 7: 230a BW

door de Raad voor Onroerende Zaken (ROZ) op 30 januari 2015 vastgesteld en tevens gepubliceerd op de website www.roz.nl.

Dit model kunt u gebruiken voor het vastleggen van de rechtsverhoudingen tussen Huurder en Verhuurder bij de huur en verhuur van bedrijfsruimte in de zin van artikel 7:230a Burgerlijk Wetboek.
U kunt dit model terug vinden op de website van de ROZ: www.roz.nl.
Ook voor de van de Huurovereenkomst deel uitmakende Algemene bepalingen en voor de Handleiding wordt u verwezen naar de website www.roz.nl.
Let wel dat u bij het opstellen van een nieuwe huurovereenkomst het meeste recente model gebruikt. Dat geldt ook voor de Algemene bepalingen, waarnaar in artikel 2.1 van de Huurovereenkomst wordt verwezen.

HUUROVEREENKOMST KANTOORRUIMTE
en andere bedrijfsruimte in de zin van artikel 7:230a BW

ONDERGETEKENDEN

1] ……

[**gevestigd/wonende***] te ……

hierna te noemen '**Verhuurder**',

ingeschreven in het handelsregister van de Kamers van Koophandel onder nummer ……

vertegenwoordigd door ……

EN

2] ……..

[**gevestigd/wonende***] te ……

hierna te noemen '**Huurder**',

ingeschreven in het handelsregister van de Kamers van Koophandel onder nummer ……

omzetbelastingnummer ……..

vertegenwoordigd door ……

NEMEN HET VOLGENDE IN AANMERKING:
……..

*) doorhalen wat niet van toepassing is en eventueel aanvullen.

paraaf Verhuurder paraaf Huurder

ZIJN OVEREENGEKOMEN

Het gehuurde, bestemming
1.1 Verhuurder verhuurt aan Huurder en Huurder huurt van Verhuurder de bedrijfsruimte (hierna 'gehuurde'), gelegen…….
kadastraal bekend……..ter grootte van in totaal circa ……. m² [**b.v.o./v.v.o./anders***] gemeten volgens……...
Het gehuurde is nader aangeduid op de als bijlage 1 bij deze huurovereenkomst gevoegde en door partijen geparafeerde plattegrond/tekening. De staat van het gehuurde op de opleveringsdatum is beschreven in het als bijlage 2 aan te hechten en door partijen te paraferen proces-verbaal van oplevering.
1.2 Het gehuurde zal door of vanwege Huurder uitsluitend worden bestemd om te worden gebruikt als……..
1.3 Het is Huurder niet toegestaan zonder voorafgaande schriftelijke toestemming van Verhuurder een andere bestemming aan het gehuurde te geven dan omschreven in artikel 1.2.
1.4 De hoogst toelaatbare belasting van de vloeren van het gehuurde bedraagt [**zoveel als bouwkundig is toegestaan / …. kN/m2***] .
1.5 Huurder heeft bij het aangaan van de huurovereenkomst [**wel / niet***] een kopie van het energielabel, als bedoeld in het Besluit energieprestatie gebouwen, ontvangen ten aanzien van het gehuurde.
1.6 Indien blijkt dat de in artikel 1.1 genoemde oppervlakte niet juist is komen partijen overeen dat:
[**een verschil met de daadwerkelijke grootte (onder- dan wel overmaat) geen verschil zal hebben voor de huurprijs***]
of
[**bij een verschil met de daadwerkelijke grootte, groter dan…..% het meerdere zal worden verrekend***].

Voorwaarden
2.1 Van deze huurovereenkomst maken deel uit de "ALGEMENE BEPALINGEN HUUROVEREENKOMST KANTOORRUIMTE en andere bedrijfsruimte in de zin van artikel 7:230a BW", gedeponeerd bij de griffie van de rechtbank te Den Haag op 17 februari 2015 en aldaar ingeschreven onder nummer 15/21, (hierna te noemen "algemene bepalingen"). De inhoud van deze algemene bepalingen is partijen bekend. Huurder en Verhuurder hebben een exemplaar van de algemene bepalingen ontvangen.
2.2 De algemene bepalingen waarnaar in artikel 2.1 wordt verwezen, zijn van toepassing behoudens voor zover daarvan in deze huurovereenkomst uitdrukkelijk is afgeweken of toepassing daarvan ten aanzien van het gehuurde niet mogelijk is.

Duur, verlenging en opzegging
3.1 Deze huurovereenkomst gaat in op……..(hierna 'ingangsdatum') en is aangegaan voor [**een periode van……. jaar en loopt tot en met …….. / onbepaalde tijd***].
3.2 Na het verstrijken van de in artikel 3.1 genoemde periode wordt deze huurovereenkomst behoudens beëindiging van deze huurovereenkomst door opzegging door [**uitsluitend Huurder / Huurder of Verhuurder***] in overeenstemming met artikelen 3.3 en 3.4 voortgezet voor [**een aansluitende periode van……jaar, derhalve tot en met……. / onbepaalde tijd***].
Deze huurovereenkomst wordt vervolgens voortgezet voor [[**een***] **aansluitende periode**[**n***] **van ……. jaar / onbepaalde tijd***].
3.3 Beëindiging van deze huurovereenkomst vindt plaats door opzegging door Huurder aan Verhuurder of door Verhuurder aan Huurder tegen het einde van de lopende huurperiode of, ingeval van een huurovereenkomst voor onbepaalde tijd tegen ieder tijdstip, met inachtneming van een termijn van [**één jaar / ……maand**[**en***]*].
3.4 Opzegging dient te geschieden bij deurwaardersexploot of per aangetekend schrijven.

*) doorhalen wat niet van toepassing is en eventueel aanvullen.

paraaf Verhuurder paraaf Huurder

Huurprijs, omzetbelasting, servicekosten, huurprijsaanpassing, betalingsverplichting, betaalperiode

4.1 De aanvangshuurprijs van het gehuurde bedraagt op de ingangsdatum op jaarbasis €…….
(zegge: ……).

4.2 Partijen komen overeen dat Verhuurder [**wel**/**geen***] omzetbelasting over de huurprijs in rekening brengt.
Indien géén met omzetbelasting belaste verhuur wordt overeengekomen is Huurder naast de huurprijs een afzonderlijke vergoeding aan Verhuurder verschuldigd, ter compensatie van het nadeel dat Verhuurder c.q. diens rechtsopvolger(s) lijdt dan wel zal lijden, omdat de omzetbelasting op de investeringen en exploitatiekosten van Verhuurder niet (meer) aftrekbaar is. Het gestelde in artikel 19 van de algemene bepalingen is dan niet van toepassing.

4.3 Partijen verklaren onder verwijzing naar artikel 11 lid 1 aanhef onder b onderdeel 5 van de Wet op de omzetbelasting 1968 een met omzetbelasting belaste verhuur te zijn overeengekomen. Tevens wordt omzetbelasting in rekening gebracht over de vergoeding die Huurder verschuldigd is voor door of vanwege Verhuurder te verzorgen levering van zaken en diensten, zoals vastgelegd in artikel 5 van de huurovereenkomst en in artikel 18 van de algemene bepalingen.
Huurder verklaart door ondertekening van deze huurovereenkomst, mede ten behoeve van de rechtsopvolger(s) van Verhuurder, dat hij het gehuurde blijvend gebruikt of blijvend laat gebruiken voor doeleinden waarvoor een volledig of nagenoeg volledig recht op aftrek van omzetbelasting op de voet van artikel 15 van de Wet op de omzetbelasting 1968 bestaat.

4.4 Het boekjaar van Huurder loopt van…….tot en met…….

4.5 De huurprijs wordt jaarlijks per……..voor het eerst met ingang van……aangepast overeenkomstig artikelen 17.1 t/m 17.3 van de algemene bepalingen.

4.6 De vergoeding die Huurder verschuldigd is voor de door of vanwege Verhuurder te verzorgen levering van zaken en diensten wordt bepaald overeenkomstig artikel 18 van de algemene bepalingen. Op deze vergoeding wordt een systeem van voorschotbetalingen met latere verrekening toegepast, zoals daar is aangegeven.

4.7 Huurder is geen omzetbelasting meer over de huurprijs verschuldigd indien het gehuurde niet langer met omzetbelasting mag worden verhuurd, terwijl partijen dat wel waren overeengekomen. Als dat het geval is, komen de in artikel 19.1 van de algemene bepalingen bedoelde vergoedingen voor de omzetbelasting in de plaats en wordt deze vergoeding bij voorbaat weergeven in artikel 4.8.

4.8. De betalingsverplichting van de Huurder bestaat uit de volgende componenten:
Per betaalperiode van…… kalendermaand(en) bedraagt bij huuringangsdatum:

- de huurprijs €
- het voorschot op de vergoeding voor door of vanwege Verhuurder verzorgde levering van zaken en diensten met de daarover verschuldigde omzetbelasting €
- in geval van belaste huur de over de huurprijs verschuldigde omzetbelasting €
- [**…% van de kale geïndexeerde huurprijs wegens BTW derving Verhuurder op de exploitatiekosten (niet zijnde servicekosten)***] €
- [BTW schade als gevolg van niet aftrekbaarheid BTW van de stichtingskosten van het gehuurde. Dit bedrag is niet meer verschuldigd per [**…….einddatum herzieningsperiode***] als gevolg van aflopen herzieningsperiode*] Dit bedrag wordt niet geïndexeerd. €

totaal €

zegge:

4.9 Met het oog op de ingangsdatum heeft de eerste betaling van Huurder betrekking op de periode van…….. tot en met …….en is het over deze eerste periode verschuldigde bedrag € ……..
Huurder zal dit bedrag voldoen vóór of op……..

4.10 De uit hoofde van deze huurovereenkomst door Huurder aan Verhuurder te verrichten periodieke betalingen als weergegeven in artikel 4.8 zijn in één bedrag bij vooruitbetaling verschuldigd in euro's en moeten vóór of op de eerste dag van de periode waarop de betalingen betrekking hebben volledig zijn voldaan.

4.11 Tenzij anders vermeld, luiden alle bedragen in deze huurovereenkomst en de daarvan deel uitmakende algemene bepalingen exclusief omzetbelasting.

*) doorhalen wat niet van toepassing is en eventueel aanvullen.

paraaf Verhuurder paraaf Huurder

Kosten van levering van zaken en diensten
5.1. Door of vanwege Verhuurder wordt de levering van de volgende zaken en diensten verzorgd:
……..
5.2 Verhuurder is bevoegd na overleg met Huurder de in artikel 5.1 genoemde levering van zaken en diensten naar soort en omvang te wijzigen of te laten vervallen.

Zekerheden
6.1 Huurder zal voor de ingangsdatum**:**
[**een bankgarantie doen stellen voor** / **een waarborgsom betalen ter grootte van***] een bedrag van € ……. (zegge:…….).
6.2 Over de waarborgsom wordt [**wel** / **geen***] rente vergoed.

Beheerder
7.1 Totdat Verhuurder anders meedeelt, treedt als beheerder op……..
7.2 Tenzij schriftelijk anders overeengekomen, dient Huurder voor wat betreft de inhoud en alle verdere aangelegenheden betreffende deze huurovereenkomst met de beheerder contact op te nemen.
7.3 De huuropzegging moet tevens aan de Verhuurder worden gezonden.

Incentives
8 Partijen verklaren dat er tussen partijen geen andere incentives zijn overeengekomen dan in deze huurovereenkomst vermeld.

Asbest/Milieu
9.1 [**Aan Verhuurder is niet bekend** / **Aan Huurder is bekend***] dat in het gehuurde asbest is verwerkt. De onbekendheid van Verhuurder met de aanwezigheid van asbest in het gehuurde houdt uitdrukkelijk geen garantie in van Verhuurder dat er geen asbest aanwezig is.
9.2 [**Aan Verhuurder is niet bekend** / **Aan Huurder is bekend***] dat in, op of aan het gehuurde een verontreiniging aanwezig is die van dien aard is dat op grond van geldende wetgeving ten tijde van het tekenen van de huurovereenkomst het nemen van maatregelen noodzakelijk is. De onbekendheid van Verhuurder met aanwezigheid van een verontreiniging in, op of aan het gehuurde ten tijde van het tekenen van de huurovereenkomst houdt uitdrukkelijk geen garantie in van Verhuurder dat er geen verontreiniging aanwezig is.

Duurzaamheid/Green lease
10 Partijen onderkennen het belang van duurzaamheid en komen overeen elkaar te ondersteunen in het behalen van de gezamenlijk geformuleerde c.q. te formuleren doelstelling en op regelmatige basis de voortgang te bespreken.

Bijzondere bepalingen
11

*) doorhalen wat niet van toepassing is en eventueel aanvullen.

paraaf Verhuurder paraaf Huurder

Aldus opgemaakt en ondertekend in voud

plaats	datum	plaats	datum
(naam Verhuurder)		(naam Huurder)	
.....		.....	
(handtekening Verhuurder)		(handtekening Huurder)	

Bijlagen: *)

[ ] plattegrond/tekening van het gehuurde.
[ ] proces-verbaal van oplevering (toe te voegen ten tijde van oplevering).
[ ] meting volgens…..
[ ] energielabel.
[ ] algemene bepalingen.
[ ] bankgarantie
[ ] milieuonderzoek.
[ ] uittreksel handelsregister Kamer van Koophandel Verhuurder.
[ ] uittreksel handelsregister Kamer van Koophandel Huurder.
[ ] kopie paspoort [**rechtsgeldig vertegenwoordiger Verhuurder***].
[ ] kopie paspoort [**rechtsgeldig vertegenwoordiger Huurder***].

Afzonderlijke handtekening[**en***] van Huurder[**s***] voor de ontvangst van een eigen exemplaar van de 'ALGEMENE BEPALINGEN HUUROVEREENKOMST KANTOORRUIMTE en andere bedrijfsruimte in de zin van artikel 7:230a BW' als genoemd in artikel 2.1.

Handtekening[**en***] Huurder[**s***]:

*) doorhalen wat niet van toepassing is en eventueel aanvullen.

paraaf Verhuurder paraaf Huurder

ALGEMENE BEPALINGEN HUUROVEREENKOMST KANTOORRUIMTE
en andere bedrijfsruimte in de zin van artikel 7: 230a BW

Omvang gehuurde
1 Onder het gehuurde zijn mede begrepen de in het gehuurde aanwezige installaties en voorzieningen, voor zover die in het bij deze huurovereenkomst als bijlage toe te voegen door partijen geparafeerde proces-verbaal van oplevering niet zijn uitgezonderd.

Geschiktheid van het gehuurde
2.1 Voor de vraag of huurgenotsbeperkende feiten en omstandigheden kwalificeren als een gebrek in de zin van artikel 7: 204 Burgerlijk Wetboek, is van belang wat Huurder bij aanvang van de huurovereenkomst redelijkerwijs mocht verwachten ten aanzien van het gehuurde.
2.2 Voor zover Verhuurder voor het aangaan van de huurovereenkomst kennis heeft van feiten of omstandigheden die in de weg staan aan het gebruik van het gehuurde door Huurder conform de overeengekomen bestemming, zal Verhuurder zulks aan Huurder meedelen.
2.3 Huurder is gehouden het gehuurde voor het aangaan van de huurovereenkomst grondig te (doen) inspecteren om na te gaan of het gehuurde geschikt is, of door of vanwege Huurder geschikt kan worden gemaakt, voor de overeengekomen bestemming die Huurder daaraan moet geven.

Staat van het gehuurde bij aanvang huurovereenkomst
3.1 Het gehuurde wordt bij aanvang van de huur door Verhuurder opgeleverd en door Huurder aanvaard in een goed onderhouden staat, tenzij partijen schriftelijk anders zijn overeengekomen. Indien bij aanvang van de huurovereenkomst geen proces-verbaal van oplevering wordt opgesteld, geldt in afwijking van artikel 7:224 lid 2 BW dat Huurder het gehuurde in goede staat, zonder gebreken en vrij van schade, heeft ontvangen.
3.2 De algemene, de bouwkundige en de technische staat van het gehuurde waarin Huurder het gehuurde bij aanvang van de huurovereenkomst aanvaardt, wordt door Huurder en Verhuurder vastgelegd in een als bijlage aan de huurovereenkomst toe te voegen en door of namens partijen te ondertekenen proces-verbaal van oplevering. Dit proces-verbaal van oplevering maakt deel uit van de huurovereenkomst.

(Overheids)voorschriften en vergunningen
4.1 Zowel op als na ingangsdatum als bedoeld in artikel 3.1 van de huurovereenkomst is Verhuurder verantwoordelijk voor het verkrijgen en behouden van de vereiste vergunningen, ontheffingen en toestemmingen die benodigd zijn voor het gebruik van het gehuurde zoals genoemd in artikel 1.1 van de huurovereenkomst, onverminderd het bepaalde in artikel 4.4 en 4.5.
4.2 De aan het verkrijgen van de in artikel 4.1 bedoelde vergunning ,ontheffing of toestemming verbonden kosten, alsmede de kosten van aanpassingen van het gehuurde om aan de voorwaarden van de vergunning, ontheffing of toestemming te voldoen, zijn voor rekening van Verhuurder, echter onverminderd het gestelde in artikelen 11.2 en 11.5 over de onderhouds-, herstel- en vernieuwingsverplichtingen van Huurder ten aanzien van reeds van het gehuurde deeluitmakende voorzieningen.
4.3 Zowel bij als na het aangaan van de huurovereenkomst is Huurder verantwoordelijk voor het verkrijgen en het behouden van alle overige vereiste, niet onder artikel 4.1 vallende vergunningen, ontheffingen en toestemmingen die benodigd zijn voor het gebruik van het gehuurde in overeenstemming met de in artikel 1.2 van de huurovereenkomst overeengekomen bestemming die Huurder daaraan moet geven. Hieronder vallen tevens alle meldingen die van overheidswege verplicht zijn/worden gesteld ter zake van het gebruik van het gehuurde in overeenstemming met de hiervoor bedoelde overeengekomen bestemming. Met de hiervoor bedoelde meldingen van overheidswege worden onder meer verstaan meldingen die op grond van het meest recente Bouwbesluit en het meest recente Besluit algemene regels voor inrichtingen milieubeheer (Activiteitenbesluit) verplicht zijn.
4.4 Weigering of intrekking van een vergunning, ontheffing of toestemming als bedoeld in artikel 4.3 levert geen gebrek op, tenzij voornoemde weigering of intrekking het gevolg is van een doen of nalaten van Verhuurder.

4.5 De aan het verkrijgen van de in artikel 4.3 bedoelde vergunning, ontheffing of toestemming verbonden kosten, alsmede de kosten van aanpassingen van het gehuurde om aan de voorwaarden van de vergunning, ontheffing of toestemming te voldoen, zijn voor rekening van Huurder echter onverminderd het gestelde in artikelen 11.2 en 11.4 over de onderhouds-, herstel- en vernieuwingsverplichtingen van Verhuurder ten aanzien van reeds van het gehuurde deel uitmakende voorzieningen.

Gebruik
5.1 Huurder zal het gehuurde - gedurende de gehele duur van de huurovereenkomst - daadwerkelijk, geheel, behoorlijk en zelf gebruiken uitsluitend overeenkomstig de in de huurovereenkomst aangegeven bestemming. Huurder zal hierbij bestaande beperkte rechten, kwalitatieve verplichtingen en de van overheidswege en vanwege de nutsbedrijven gestelde of nog te stellen eisen (waaronder eisen ten aanzien van het bedrijf van Huurder, ten aanzien van het gebruik van het gehuurde, alsmede ten aanzien van alles wat in of aan het gehuurde aanwezig is) in acht nemen. Huurder zal het gehuurde voorzien en voorzien houden van voldoende inrichting en inventaris. Onder nutsbedrijven wordt in deze huurovereenkomst tevens verstaan soortgelijke bedrijven die zich bezig houden met de levering, het transport en de meting van het verbruik van energie, water e.d.
5.2 Huurder zal zich gedragen naar de bepalingen van de wet en de plaatselijke verordeningen alsmede naar de gebruiken omtrent huur en verhuur, de voorschriften van de overheid, van de nutsbedrijven en de verzekeraars. Huurder mag ten aanzien van werkzaamheden, die betrekking hebben op beveiliging, brandpreventie en lifttechniek, slechts bedrijven inschakelen waarmee Verhuurder tevoren heeft ingestemd en die zijn erkend door het Nationaal Centrum voor Preventie (NCP) respectievelijk door de Stichting Nederlands Instituut voor Lifttechniek. Verhuurder zal de instemming niet op onredelijke gronden weigeren. Als in het kader van door of vanwege Verhuurder te verzorgen leveringen en diensten is overeengekomen dat de hierboven weergegeven werkzaamheden in opdracht van Verhuurder geschieden, mag Huurder die werkzaamheden niet zelf (laten) uitvoeren. Huurder zal zich te allen tijde houden aan de gebruiksvoorschriften die door deze bedrijven worden afgegeven. Eveneens zal Huurder de mondelinge en schriftelijke aanwijzingen in acht nemen door of namens Verhuurder gegeven in het belang van een behoorlijk gebruik van het gehuurde en van de binnen- en buitenruimten, installaties en voorzieningen van het gebouw of complex van gebouwen waarvan het gehuurde deel uitmaakt. Hiertoe behoren ook de redelijke aanwijzingen met betrekking tot onderhoud, aanzien, geluidsniveau, orde, brandveiligheid, parkeergedrag en het goed functioneren van de installaties respectievelijk het gebouw of complex van gebouwen waarvan het gehuurde deel uitmaakt.
5.3 Huurder mag bij het gebruik van het gebouw of complex van gebouwen waarvan het gehuurde deel uitmaakt geen hinder of overlast veroorzaken. Huurder zal er voor zorgdragen dat vanwege hem aanwezige derden dit evenmin doen.
5.4 Huurder heeft het recht en de plicht tot het gebruik van de gemeenschappelijke voorzieningen en diensten welke in het belang van het goed functioneren van het gebouw of complex van gebouwen, waartoe het gehuurde behoort, ter beschikking zijn of zullen zijn.
5.5 Verhuurder heeft het recht om met betrekking tot het plaatsen van (licht-)reclame en of aanduidingen of door Huurder gewenste veranderingen of toevoegingen of overige van buitenaf zichtbare wijzigingen voorschriften te stellen, en zal toestemming daarvoor niet op onredelijke gronden te onthouden. Verhuurder mag voorschriften geven onder meer ten aanzien van de uitvoering, plaats, afmeting en materiaalkeuze. Huurder is gehouden tot de naleving van die voorschriften en van die van daartoe bevoegde instanties met betrekking tot door Huurder aangebrachte veranderingen of toevoegingen.
5.6 Voor het plaatsen van antenne-installaties of andere doeleinden heeft Verhuurder het recht om voor zichzelf, voor Huurder(s) of derden te beschikken over de daken, buitengevels, de niet voor publiek of Huurder toegankelijke ruimten, de onroerende aanhorigheden binnen het gebouw of complex van gebouwen, alsook over de tuinen en erven van dat gebouw of complex van gebouwen. Als Verhuurder van dit recht gebruik wenst te maken zal Verhuurder Huurder hierover tevoren informeren en zal Verhuurder bij de uitoefening van dit recht rekening houden met de belangen van Huurder.
5.7 Verhuurder kan Huurder de toegang tot het gehuurde weigeren indien Huurder op het moment dat deze het gehuurde voor het eerst in gebruik wenst te nemen, (nog) niet aan zijn verplichtingen uit de huurovereenkomst heeft voldaan. Dit heeft geen gevolgen voor de ingangsdatum als bedoeld in artikel 3.1 van de huurovereenkomst en de uit de huurovereenkomst voortvloeiende verplichtingen van Huurder.

Onderhuur
6.1 Behoudens voorafgaande schriftelijke toestemming van Verhuurder is het Huurder niet toegestaan het gehuurde geheel of gedeeltelijk aan derden in huur, onderhuur of gebruik af te staan, ofwel de huurrechten geheel of gedeeltelijk aan derden over te dragen of in te brengen in een personenvennootschap of rechtspersoon.

6.2 Ingeval Huurder handelt in strijd met artikel 6.1, verbeurt Huurder aan Verhuurder per dag dat de overtreding voortduurt een direct opeisbare boete, gelijk aan tweemaal de op dat moment voor Huurder geldende huurprijs per dag, onverminderd het recht van Verhuurder om nakoming dan wel ontbinding van de huurovereenkomst, alsmede schadevergoeding te vorderen.
6.3 Het is Huurder toegestaan onder te verhuren of ruimte in gebruik te geven aan een groepsmaatschappij in de zin van artikel 2:24b Burgerlijk Wetboek mits dat past binnen het gebruik zoals bedoeld in artikel 1.2 van de huurovereenkomst en deze onderhuurder/gebruiker de ruimte niet zal onderverhuren en/of in gebruik zal geven aan een derde. Huurder mag in de onderverhuurovereenkomst niet ten nadele van de hoofdhuurovereenkomst afwijken. Het voorgaande laat onverlet de verplichtingen van Huurder uit de huurovereenkomst. Huurder blijft het enige aanspreekpunt voor Verhuurder.

Milieu en energielabel
7.1 Huurder en Verhuurder zullen richtlijnen, voorschriften of aanwijzingen van de overheid of andere bevoegde instanties ten aanzien van het (gescheiden) aanbieden van afvalstoffen nauwgezet naleven. Bij de niet of niet volledige nakoming van deze verplichting is de nalatige partij aansprakelijk voor de daaruit voortvloeiende financiële, strafrechtelijke en mogelijke andere consequenties.
7.2 Het is Huurder niet toegestaan:
a. in, op, aan of in de directe omgeving van het gehuurde milieugevaarlijke zaken te hebben, waaronder stankverspreidende, brandgevaarlijke of ontplofbare zaken;
b. het gehuurde zodanig te gebruiken dat door dit gebruik bodem- of andere milieuverontreiniging optreedt.
7.3 Verhuurder vrijwaart Huurder niet tegen overheidsbevelen tot het uitvoeren van een milieuonderzoek ter zake van het gehuurde dan wel het treffen van maatregelen in geval onder, in, aan of rondom het gehuurde verontreiniging wordt aangetroffen.
7.4 Voor zover Verhuurder gehouden is een energielabel in het gehuurde te afficheren, zal huurder zonder daar verdere voorwaarden aan te stellen, verhuurder daartoe in de gelegenheid stellen.
7.5 Het is Huurder en Verhuurder niet toegestaan zonder schriftelijke toestemming van Verhuurder en Huurder veranderingen/toevoegingen aan te brengen in of aan het gehuurde waardoor de energie-index van het gehuurde die is vermeld in het energielabel, als bedoeld in artikel 1.5 van de huurovereenkomst, aantoonbaar verslechtert.

Gedragsregels, voorschriften en verbodsbepalingen
8.1 Huurder zal bij het gebruik van het gehuurde geen hinder of overlast veroorzaken, noch schade veroorzaken in, op, aan of onder het gehuurde of complex van gebouwen waarvan het gehuurde deel uit maakt. Onder schade aan het gehuurde wordt onder andere verstaan het gebruiken van transportmiddelen waardoor vloeren en wanden (kunnen) worden beschadigd. Huurder zal er voor zorgdragen dat vanwege hem aanwezige derden dit evenmin doen. Dit geldt eveneens ten aanzien van het gebouw of complex van gebouwen waarvan het gehuurde deel uitmaakt.
8.2 Het is Huurder niet toegestaan:
a. vloeren van het gehuurde en van het gebouw of complex van gebouwen waarvan het gehuurde deel uitmaakt hoger te belasten dan in de huurovereenkomst is aangegeven dan wel bouwkundig is toegestaan;
b. wijzigingen of voorzieningen aan te brengen in, op of aan het gehuurde die in strijd zijn met voorschriften van de overheid en van de nutsbedrijven dan wel met de voorwaarden waaronder de eigenaar van het gehuurde de eigendom van het gehuurde heeft verworven of met andere beperkte rechten, of die voor andere Huurders of omwonenden tot overlast leiden dan wel deze hinderen in hun gebruik.
8.3 Het is Huurder zonder voorafgaande schriftelijke toestemming van Verhuurder niet toegestaan de dienst- en installatieruimten, de platten, daken, goten en de niet voor algemeen gebruik bestemde plaatsen van het gehuurde of van het gebouw of complex van gebouwen waarvan het gehuurde deel uitmaakt, te betreden of te laten betreden of vervoermiddelen te stallen op andere dan de daartoe bestemde plaatsen.
8.4 Met betrekking tot de tijden waarbinnen en de wijze waarop laden en lossen plaatsvindt, zal Huurder zich gedragen naar de voorschriften van de overheid en andere bevoegde instanties, alsook naar de redelijke aanwijzingen van Verhuurder.
8.5 Huurder zal vluchtwegen en nooddeuren in het gehuurde en het gebouw of complex van gebouwen waarvan het gehuurde deel uitmaakt te allen tijde vrij houden en de bereikbaarheid van brandblusvoorzieningen garanderen.
Ook Verhuurder zal zich onthouden van het blokkeren van bedoelde vluchtwegen en nooddeuren.
8.6 Indien tot het gehuurde een lift, rolbaan, roltrap, automatisch deurmechanisme of een soortgelijke voorziening behoort dan wel het gehuurde door middel of met behulp van een of meer van genoemde of soortgelijke voorzieningen bereikbaar is, zal men uitsluitend op eigen risico van deze voorzieningen gebruik kunnen maken. Huurder is aansprakelijk voor het goed en vakkundig gebruik van de eventueel tot het gehuurde behorende technische installaties.

Schade
9.1 Huurder zal Verhuurder onverwijld in kennis stellen van een gebrek en van de (dreigende) schade die uit dat gebrek of uit een andere oorzaak of omstandigheid voortvloeit. Huurder geeft Verhuurder daarbij een- gelet op de aard van het gebrek- redelijke termijn, om een aanvang te maken met het verhelpen van een voor rekening van Verhuurder komend gebrek. Huurder zal Verhuurder deze kennisgeving waaronder mede begrepen de redelijke termijn zo spoedig mogelijk schriftelijk bevestigen.
9.2 Huurder neemt tijdig passende maatregelen ter voorkoming en beperking van schade aan het gehuurde en aan het gebouw of complex van gebouwen waarvan het gehuurde deel uitmaakt.
Indien de (dreigende) schade niet aan Huurder is toe te rekenen en de kosten voor passende maatregelen aantoonbaar en redelijk zijn zal Verhuurder deze kosten op eerste verzoek van Huurder aan Huurder vergoeden.

Aansprakelijkheid
10.1 Huurder is jegens Verhuurder aansprakelijk voor alle schade aan het gehuurde, tenzij Huurder bewijst dat de schade hem en de personen waarvoor Huurder verantwoordelijk is, niet is toe te rekenen.
10.2 Huurder vrijwaart Verhuurder tegen boetes die Verhuurder worden opgelegd door gedragingen of nalatigheden van Huurder.
10.3 Verhuurder is niet aansprakelijk voor schade ten gevolge van een gebrek en Huurder kan in geval van een gebrek geen aanspraak maken op huurprijsvermindering en verrekening, behoudens de bevoegdheid tot verrekening als bedoeld in artikel 7: 206 lid 3 Burgerlijk Wetboek.
10.4 Het gestelde in artikel 10.3 is in de navolgende omstandigheden niet van toepassing:
- ingeval van schade indien een gebrek een gevolg is van een toerekenbare ernstige tekortkoming van Verhuurder;
- indien Verhuurder een gebrek bij het aangaan van de huurovereenkomst kende en met Huurder daaromtrent geen nadere afspraken heeft gemaakt;
-indien het gehuurde op de ingangsdatum als bedoeld in artikel 3.1 van de huurovereenkomst niet geschikt blijkt te zijn voor het gebruik als bedoeld in artikel 1.1 van de huurovereenkomst door aan Verhuurder toe te rekenen omstandigheden;
- indien Verhuurder een gebrek bij het aangaan van de huurovereenkomst behoorde te kennen en Huurder daarvan middels zijn onderzoeksplicht in artikel 2.3 niet op de hoogte had kunnen of behoren te zijn dan wel dienaangaande geen onderzoek hoefde te doen;
-indien Verhuurder de door Huurder schriftelijk gestelde redelijke termijn als bedoeld in artikel 9.1 om een aanvang te maken met het verhelpen van een voor rekening van Verhuurder komend gebrek, niet in acht heeft genomen.

Kosten onderhoud, herstel en vernieuwingen, inspecties en keuringen
11.1 De in de huurovereenkomst en algemene bepalingen gebruikte termen onderhoud, herstel en vernieuwing worden als volgt gedefinieerd:
- onderhoud: het ervoor zorgdragen dat een zaak in een goede toestand blijft, althans in de staat blijft zoals die bij ingangsdatum van de huurovereenkomst bestond, behoudens normale gebruiksslijtage;
- herstel: het terugbrengen dan wel vervangen van een zaak in een staat die het mogelijk maakt dat deze zaak weer kan worden gebruikt zoals bij ingangsdatum van de huurovereenkomst;
- vernieuwing: het vervangen van een zaak als gevolg van het bereiken van het einde van de technische levensduur van die zaak.
11.2 Voor rekening van Verhuurder zijn de kosten van de hierna in artikel 11.4 weergegeven onderhouds-, herstel-, en vernieuwingswerkzaamheden aan het gehuurde. Voor rekening van Huurder zijn de kosten van de overige onderhouds-, herstel-, en vernieuwingswerkzaamheden, waaronder begrepen de kosten van inspecties en keuringen, aan het gehuurde.
Indien het gehuurde deel uitmaakt van een gebouw of complex van gebouwen, geldt het bovenstaande eveneens voor de kosten van de bedoelde werkzaamheden ten behoeve van het gebouw of complex van gebouwen waarvan het gehuurde deel uitmaakt, zoals werkzaamheden aan gemeenschappelijke installaties, ruimten en andere gemeenschappelijke voorzieningen een en ander pro rata parte.
11.3 Tenzij partijen anders zijn overeengekomen, worden de in artikelen 11.2,11.4 en 11.5 bedoelde werkzaamheden verricht door, dan wel in opdracht van de partij voor wiens rekening die werkzaamheden zijn. Partijen dienen tijdig tot het verrichten van bedoelde werkzaamheden over te gaan.
11.4 Voor rekening van Verhuurder zijn de kosten van:
a. onderhoud, herstel en vernieuwing van constructieve onderdelen van het gehuurde, zoals funderingen, kolommen, balken, bouwvloeren, daken, platten, bouwmuren, buitengevels;
b. onderhoud, herstel en vernieuwing van tot het gehuurde behorende trappen, traptreden, rioleringen, goten, buitenkozijnen, tenzij Huurder zijn verplichtingen op grond van artikel 11.5 sub k niet is nagekomen;

c. vervanging van onderdelen en vernieuwing van tot het gehuurde behorende installaties;
d. buitenschilderwerk.
De onder a t/m d genoemde werkzaamheden zijn voor rekening van Verhuurder, tenzij het werkzaamheden betreft die moeten worden beschouwd als kleine herstellingen waaronder begrepen gering en dagelijks onderhoud in de zin van de wet dan wel werkzaamheden aan zaken die niet door of vanwege Verhuurder in, op of aan het gehuurde zijn aangebracht.
11.5 Ter verduidelijking dan wel in afwijking of in aanvulling op artikel 11.2 zijn voor rekening van Huurder:
a. het uitwendig onderhoud indien en voor zover het werkzaamheden betreft die moeten worden beschouwd als kleine herstellingen waaronder begrepen gering en dagelijks onderhoud in de zin van de wet, alsmede inwendig onderhoud niet zijnde onderhoud als bedoeld in artikel 11.4 een en ander onverminderd het hier verder bepaalde;
b. onderhoud, herstel en vernieuwing van schakelaars, lampen, verlichting (inclusief armaturen), accu's, binnenschilderwerk, stopcontacten, hang- en sluitwerk, beglazing en glasdeuren, spiegel-, venster- en andere ruiten;
c. onderhoud en herstel van rolluiken, jaloezieën, markiezen en andere zonwering;
d. onderhoud en herstel van het systeemplafond inclusief armaturen, belinstallaties, gootstenen, pantryinrichting, sanitair;
e. onderhoud en herstel van leidingen en kranen van gas, water en elektriciteit, brand-, braak- en diefstalpreventieve voorzieningen met al wat daartoe behoort;
f. onderhoud en herstel van erfafscheidingen, tuin en erf waaronder de bestrating;
g. het periodiek en correctief onderhoud, alsmede de periodieke keuringen en het afstandsbeheer van de tot het gehuurde behorende technische installaties, waaronder mede begrepen vernieuwing van kleine onderdelen. Deze werkzaamheden mogen slechts worden verricht door bedrijven die door Verhuurder zijn goedgekeurd;
h. al dan niet van overheidswege voorgeschreven en andere redelijkerwijs noodzakelijk geachte (zowel periodieke als incidentele) keuringen en inspecties op het gebied van deugdelijkheid en veiligheid of ter controle van de goede werking van tot het gehuurde of zijn onroerende aanhorigheden behorende (al dan niet technische) installaties; bedoelde keuringen en inspecties worden in opdracht van Verhuurder verricht; wat betreft de daaraan verbonden kosten is het hierna gestelde in artikelen 18.3 tot en met 18.8 voor zover mogelijk van toepassing;
i. onderhoud, herstel en vernieuwing van stoffering en vloerbedekking als mede zaken die door of vanwege Huurder al dan niet uit hoofde van een aan Huurder door Verhuurder ter beschikking gestelde stelpost, zijn of worden aangebracht;
j. de zorg voor het schoonmaken en schoonhouden van het gehuurde, zowel in- als uitwendig, waaronder mede wordt verstaan het schoonhouden van ramen, van rolluiken, jaloezieën, markiezen en andere zonwering, kozijnen en gevels van het gehuurde, alsook het verwijderen van graffiti aangebracht op het gehuurde;
k. de zorg voor het legen van vetvangputten, het schoonmaken en ontstoppen van putten, goten en alle afvoeren/ rioleringen tot aan de gemeentelijke hoofdriolering van het gehuurde, het vegen van schoorstenen en het reinigen van ventilatiekanalen.
11.6 Onderhoud, herstel en vernieuwing van door of vanwege Huurder aangebrachte veranderingen en toevoegingen zijn voor rekening van Huurder.
11.7 Indien Huurder na aanmaning nalaat voor zijn rekening komend onderhoud of herstel uit te voeren – dan wel indien naar het oordeel van Verhuurder deze werkzaamheden op onoordeelkundige of slechte wijze zijn uitgevoerd – is Verhuurder gerechtigd de door hem noodzakelijk geachte onderhouds-, herstel of vernieuwingswerkzaamheden voor rekening en risico van Huurder te verrichten of te doen verrichten. Indien de voor rekening van Huurder komende werkzaamheden geen uitstel kunnen gedogen, is Verhuurder gerechtigd deze terstond voor Huurders rekening te verrichten of te doen verrichten.
11.8 Bij door Verhuurder uit te voeren onderhouds-, herstel-, of vernieuwingswerkzaamheden zal Verhuurder tevoren met Huurder overleggen op welke wijze daarbij zoveel mogelijk met diens belangen rekening kan worden gehouden. Vinden deze werkzaamheden op wens van Huurder buiten normale werktijden plaats, dan komen de extra kosten daarvan voor rekening van Huurder.
11.9 Huurder is aansprakelijk voor het goed en vakkundig gebruik van de technische installaties in het gehuurde. Huurder is eveneens aansprakelijk voor het door hem of in zijn opdracht aan de installaties uitgevoerd onderhoud. De omstandigheid dat het onderhoud is uitgevoerd door een door Verhuurder goedgekeurd bedrijf ontslaat Huurder niet van deze aansprakelijkheid.
11.10 Indien Huurder en Verhuurder overeen zijn gekomen dat de voor rekening van Huurder komende werkzaamheden in verband met het onderhoud, herstel en vernieuwing in, op of aan het gehuurde, het gebouw of complex van gebouwen waarvan het gehuurde deel uitmaakt als genoemd in artikelen 11.2, 11.5 en 11.6 niet in opdracht van Huurder maar van Verhuurder worden uitgevoerd, dan worden de kosten

hiervan door Verhuurder aan Huurder doorberekend. In een aantal gevallen wordt daartoe door Verhuurder onderhoudscontracten afgesloten.

Veranderingen en toevoegingen door Huurder
12.1 Huurder zal Verhuurder te allen tijde tijdig tevoren schriftelijk informeren over iedere verandering of toevoeging. Hieronder vallen onder meer doch niet uitsluitend alle wijzigingen die een effect zouden kunnen hebben op de op het gehuurde toepasselijke vergunningen. Huurder dient ervoor zorg te dragen dat hij van de partij die veranderingen en toevoegingen uitvoert, bedingt dat deze afziet van zijn retentierecht.
12.2 Zonder toestemming van Verhuurder is Huurder bevoegd veranderingen en/of toevoegingen in het gehuurde aan te brengen, die voor de exploitatie van het bedrijf van Huurder nodig zijn, mits de veranderingen en toevoegingen niet de (bouwkundige) constructie van het gehuurde en/of (technische) voorzieningen die deel uitmaken van het gehuurde of het complex van gebouwen waarvan het gehuurde deel uit maakt, betreffen of beïnvloeden.
12.3 Voor alle veranderingen en toevoegingen anders dan bedoeld in artikel 12.2 behoeft Huurder de voorafgaande schriftelijke toestemming van Verhuurder.
12.4 Onder de in artikel 12.2 bedoelde veranderingen en/of toevoegingen vallen niet veranderingen en toevoegingen aan de buitenzijde van het gehuurde, waaronder naamsaanduidingen en reclames van Huurder. Daarvoor is steeds de schriftelijke toestemming van Verhuurder nodig en dient Huurder de redelijke aanwijzingen van Verhuurder op te volgen. Verhuurder zal de toestemming niet op onredelijke gronden onthouden. Het is Huurder voorts zonder schriftelijke toestemming van Verhuurder niet toegestaan ramen en etalages af te plakken of anderszins ondoorzichtig te maken.
12.5 Huurder dient voor diens rekening voor het aanbrengen van veranderingen en/of toevoegingen in het gehuurde steeds (nader) te onderzoeken of er sprake is van aanwezigheid van asbest op de locatie waar de veranderingen en/of toevoegingen zullen plaatsvinden. Huurder dient de resultaten van dit (nader) onderzoek aan Verhuurder mee te delen en bij aanwezigheid van asbest over te gaan tot overleg met Verhuurder. Huurder vrijwaart Verhuurder voor alle mogelijke schade en gevolgen indien Huurder, bij aanwezigheid van asbest, overgaat tot het (laten) uitvoeren van genoemde werkzaamheden.
12.6 Huurder staat er voor in dat andere gebruikers van het gebouw of het complex van gebouwen waarvan het gehuurde deel uitmaakt geen hinder, schade en/of overlast van veranderingen en toevoegingen ondervinden, ongeacht of toestemming vereist is en/of is verleend.
12.7 Indien voor een verandering of toevoeging een vergunning, ontheffing of toestemming van een derde vereist is, zal Huurder deze aanvragen en zal Huurder zich houden aan alle daarop betrekking hebbende voorschriften.
12.8 Alle aan de veranderingen en toevoegingen verbonden kosten en leges zijn voor rekening van Huurdervoorzover die in opdracht van of voor rekening van Huurder zijn gemaakt.
12.9 De door Huurder al dan niet met toestemming van Verhuurder aangebrachte veranderingen en toevoegingen maken geen deel uit van het gehuurde. Verhuurder heeft met betrekking tot deze veranderingen en toevoegingen geen onderhouds-, herstel of vernieuwingsverplichting.
12.10 Huurder is aansprakelijk voor schade die het gevolg is van door of namens hem aangebrachte veranderingen en toevoegingen.
12.11 Huurder dient de door Verhuurder gegeven redelijke aanwijzingen in acht te nemen en Huurder vrijwaart Verhuurder voor aanspraken van derden voor schade veroorzaakt door Huurder aangebrachte veranderingen en voorzieningen.
12.12 Huurder zal in geval van hinder, overlast en/of (dreigende) schade vanwege een verandering of toevoeging al die maatregelen nemen om de schade ongedaan te maken en hinder en overlast te voorkomen.
12.13 Indien door Huurder aangebrachte zaken in verband met werkzaamheden aan het gehuurde of het gebouw of complex van gebouwen waarvan het gehuurde deel uitmaakt tijdelijk moeten worden verwijderd, zullen de kosten van verwijdering, eventuele opslag en het opnieuw aanbrengen voor rekening van Huurder komen.
12.14 Huurder is verplicht veranderingen en toevoegingen voor het einde van de huurovereenkomst ongedaan te maken en de daardoor ontstane schade te herstellen tenzij Verhuurder hem van deze verplichting ontslaat.
12.15 Huurder doet afstand van alle rechten en aanspraken uit ongerechtvaardigde verrijking in verband met de door of namens Huurder aangebrachte veranderingen of toevoegingen die bij het einde van de huur niet ongedaan zijn gemaakt, tenzij partijen schriftelijk anders zijn overeengekomen.

Onderhoud en renovatie door Verhuurder
13.1 Het is Verhuurder toegestaan om op, aan of in het gehuurde of het gebouw of complex van gebouwen waarvan het gehuurde deel uitmaakt of aan belendingen werkzaamheden en onderzoek te (doen) verrichten

in het kader van onderhoud, herstel en vernieuwing. Daarin zijn begrepen het aanbrengen van extra voorzieningen en wijzigingen of werkzaamheden die nodig zijn in verband met (milieu-) eisen of maatregelen van de overheid of nutsbedrijven of andere daartoe bevoegde instanties.
13.2 Als Verhuurder wenst over te gaan tot renovatie van het gehuurde zal hij Huurder een renovatievoorstel doen. Een renovatievoorstel van Verhuurder wordt vermoed redelijk te zijn, indien het de instemming heeft van tenminste 51 % van de Huurders waarvan het gehuurde bij de renovatie betrokken is en die Huurders samen tenminste 70% van het aantal m2 verhuurbaar vloeroppervlak inclusief leegstand huren van het gebouw of complex van gebouwen waarvan het gehuurde deel uitmaakt en dat bij de renovatie betrokken is. Ten behoeve van de procentuele berekening wordt Verhuurder als Huurder van het niet verhuurde aantal m2 verhuurbaar vloeroppervlak aangemerkt.
13.3 Onder renovatie wordt verstaan (gedeeltelijke) sloop, vervangende nieuwbouw, toevoegingen en veranderingen van het gehuurde of van het gebouw of complex van gebouwen waarvan het gehuurde deel uitmaakt.
13.4 Het gestelde in artikel 7: 220 leden 1, 2 en 3 Burgerlijk Wetboek is niet van toepassing. Renovatie en onderhoudswerkzaamheden van het gehuurde, ook indien ingrijpend op de ondernemingsactiviteiten van de Huurder of van het gebouw of complex van gebouwen waarvan het gehuurde deel uitmaakt, leveren voor Huurder geen gebrek op. Huurder zal onderhoudswerkzaamheden en renovatie van het gehuurde of van gebouw of complex van gebouwen waarvan het gehuurde deel uitmaakt, gedogen en Verhuurder daartoe in de gelegenheid stellen. Verhuurder zal redelijke proportionele maatregelen nemen om aantasting van het huurgenot zoveel mogelijk te beperken.
13.5 Ten aanzien van die gedeelten van het gehuurde waartoe Huurder geen exclusief gebruiksrecht heeft, zoals gemeenschappelijke ruimten, liften, (rol)trappen, trappenhuizen, gangen, toegangen en of andere onroerende aanhorigheden is het Verhuurder toegestaan de gedaante en de inrichting daarvan aan te passen en deze gedeelten van het gehuurde te verplaatsen mits het gebruik als bedoeld in artikel 1.2 van de huurovereenkomst mogelijk blijft.

Verzoeken/toestemming
14.1 Iedere afwijking/aanvulling van deze huurovereenkomst dient schriftelijk te worden overeengekomen.
14.2 Indien en voor zover in enige bepaling van deze huurovereenkomst de toestemming van Verhuurder of Huurder wordt vereist, zal Verhuurder of Huurder deze niet onredelijk weigeren en of vertragen en wordt deze alleen dan geacht te zijn verleend indien deze schriftelijk is verstrekt.
14.3 Een door Verhuurder of Huurder gegeven toestemming is eenmalig en geldt niet voor andere of opvolgende gevallen. Verhuurder of Huurder is gerechtigd om aan die toestemming redelijke voorwaarden te verbinden.

Wijziging organisatie Huurder/Verhuurder
15 Partijen zijn verplicht om elkaar telkens schriftelijk op de hoogte te stellen van voorgenomen relevante wijzigingen in zijn/haar organisatie, waaronder begrepen de vennootschapsrechtelijke structuur. De hiervoor bedoelde mededeling dient de andere partij op een zodanig tijdstip te bereiken dat deze nog tijdig alle maatregelen kan nemen ten aanzien van de voorgenomen wijziging. Onder deze maatregelen worden onder meer, doch niet uitsluitend, begrepen juridische acties, zoals het aantekenen van verzet tegen een voorstel tot juridische fusie of splitsing.

Taxatie en bezichtiging van het gehuurde
16.1 Indien Verhuurder een taxatie van het gehuurde wil (laten) verrichten, dan wel wenst over te gaan tot het verrichten van werkzaamheden in, op of aan het gehuurde is Huurder verplicht Verhuurder of degene die zich ter zake bij Huurder zal vervoegen, toegang te verlenen en tot de werkzaamheden in staat te stellen.
16.2 Ter uitvoering van het in het eerste lid vermelde zijn Verhuurder en/of alle door hem aan te wijzen personen gerechtigd het gehuurde na overleg met Huurder op werkdagen tussen 07.00 en 17.30 uur te betreden. In noodgevallen is Verhuurder gerechtigd ook zonder overleg en zo nodig buiten vermelde tijdstippen het gehuurde te betreden.
16.3 Bij voorgenomen verhuur, verkoop of veiling van het gehuurde en gedurende een jaar voor het einde van de huurovereenkomst, is Huurder verplicht, zonder daar enige aanspraak aan te ontlenen, gedurende minstens twee werkdagen per week, na voorafgaande mededeling door Verhuurder of diens gemachtigde, gelegenheid te geven tot bezichtiging van het gehuurde. Huurder zal de gebruikelijke 'te huur' of 'te koop' borden of biljetten aan of bij het gehuurde gedogen.

Huurprijswijziging
17.1 Een in artikel 4.5 van de huurovereenkomst overeengekomen wijziging van de huurprijs vindt plaats op basis van de wijziging van het maandprijsindexcijfer volgens de consumentenprijsindex (CPI) reeks alle

huishoudens (2006=100), gepubliceerd door het Centraal Bureau voor de Statistiek (CBS). De gewijzigde huurprijs wordt berekend volgens de formule: de gewijzigde huurprijs is gelijk aan de geldende huurprijs op de wijzigingsdatum, vermenigvuldigd met het indexcijfer van de kalendermaand die ligt vier kalendermaanden voor de kalendermaand waarin de huurprijs wordt aangepast, gedeeld door het indexcijfer van de kalendermaand die ligt zestien kalendermaanden voor de kalendermaand waarin de huurprijs wordt aangepast.
17.2 De huurprijs wordt niet gewijzigd indien een indexering van de huurprijs leidt tot een lagere huurprijs dan de laatst geldende. Die laatst geldende huurprijs blijft ongewijzigd, totdat bij een volgende indexering het indexcijfer van de kalendermaand die ligt vier kalendermaanden voor de kalendermaand waarin de huurprijs wordt aangepast hoger is dan het indexcijfer van de kalendermaand die ligt vier kalendermaanden voor de kalendermaand waarin de laatste huurprijsaanpassing heeft plaatsgevonden. Als dan worden bij die huurprijswijziging de indexcijfers van de in de vorige zin bedoelde kalendermaanden gehanteerd.
17.3 Een geïndexeerde huurprijs is opeisbaar verschuldigd, ook al wordt van de aanpassing aan Huurder geen afzonderlijke mededeling gedaan.
17.4 Indien het CBS bekendmaking van genoemd prijsindexcijfer staakt of de basis van de berekening daarvan wijzigt, zal een zoveel mogelijk daaraan aangepast of vergelijkbaar indexcijfer worden gehanteerd. Bij verschil van mening hieromtrent kan door de meest gerede partij aan de directeur van het CBS een uitspraak worden gevraagd die voor partijen bindend is. De eventueel hieraan verbonden kosten worden door partijen elk voor de helft gedragen.

Kosten van levering van zaken en diensten (servicekosten)
18.1 Boven de huurprijs zijn voor rekening van Huurder de kosten van levering, transport, de meting en het verbruik van water en energie ten behoeve van het gehuurde, waaronder begrepen de kosten van het aangaan van de betreffende overeenkomsten en de meterhuur, alsmede eventuele andere kosten en boetes die door de nutsbedrijven in rekening worden gebracht. Huurder dient zelf de overeenkomsten tot levering met de betrokken instanties af te sluiten, tenzij het gehuurde geen afzonderlijke aansluitingen heeft en/of Verhuurder als onderdeel van de overeengekomen levering van zaken en diensten hiervoor zorgdraagt.
18.2 Indien tussen partijen geen bijkomende levering van zaken en diensten is overeengekomen, draagt Huurder voor eigen rekening en risico en ten genoegen van Verhuurder daar zorg voor. Huurder sluit in dat geval zelf, door Verhuurder vooraf goed te keuren, servicecontracten af met betrekking tot de tot het gehuurde behorende installaties.
18.3 Indien partijen zijn overeengekomen dat door of vanwege Verhuurder bijkomende levering van, zaken en diensten wordt verzorgd, stelt Verhuurder de daarvoor door Huurder verschuldigde vergoeding vast op basis van de kosten die met de levering van zaken en diensten en de daaraan verbonden administratieve werkzaamheden zijn gemoeid. Voor zover het gehuurde deel uitmaakt van een gebouw of complex van gebouwen en de levering van zaken en diensten mede betrekking heeft op andere daartoe behorende gedeelten, stelt Verhuurder het redelijkerwijs voor rekening van Huurder komende aandeel in de kosten van die levering van zaken en diensten vast. Verhuurder hoeft daarbij geen rekening te houden met de omstandigheid dat Huurder van een of meer van deze levering van zaken en diensten geen gebruik maakt. Als een of meer gedeelten van het gebouw of complex van gebouwen niet in gebruik zijn, draagt Verhuurder er bij de bepaling van Huurders aandeel zorg voor dat dit niet hoger wordt dan wanneer het gebouw of complex van gebouwen volledig in gebruik zou zijn.
18.4 Na afloop van het servicekostenjaar verstrekt Verhuurder aan Huurder binnen 12 maanden na afloop van het jaar over elk jaar een rubrieksgewijs overzicht van de kosten van de levering van zaken en diensten, met vermelding van de wijze van berekening daarvan en van, voor zover van toepassing, het aandeel van Huurder in die kosten op zodanige wijze dat Huurder de toerekening van de kosten zelfstandig kan vaststellen. Uitgangspunt is dat Verhuurder het rubrieksgewijs overzicht binnen 12 maanden na afloop van het jaar verstrekt. Indien Verhuurder niet in staat is dit overzicht tijdig te verstrekken zal Verhuurder dit met redenen omkleed aan Huurder meedelen
De wettelijke verjaringstermijn vangt aan na afloop van het jaar waarop de servicekosten betrekking hebben.
18.5 Na het einde van de huur wordt een overzicht verstrekt over de periode waarover dit nog niet was geschied. Verstrekking van dit laatste overzicht vindt plaats na verloop van maximaal 12 maanden na afloop van het jaar waarop de servicekosten betrekking hebben tenzij Verhuurder niet in staat is dit overzicht te verstrekken. Verhuurder zal dit met redenen omkleed aan Huurder meedelen. Huurder noch Verhuurder zal voortijdig aanspraak maken op verrekening.
18.6 Wat blijkens het overzicht over de betreffende periode, rekening houdend met voorschotbetalingen, door Huurder te weinig is betaald of door Verhuurder te veel is ontvangen, wordt binnen drie maanden na verstrekking van het overzicht bijbetaald of terugbetaald. Betwisting van de juistheid van het overzicht heeft geen schorsing van deze verplichting tot betaling tot gevolg.

18.7 Verhuurder heeft het recht de levering van zaken en diensten, na overleg met Huurder, naar soort en omvang te wijzigen.
18.8 Verhuurder heeft het recht het door Huurder verschuldigde voorschot op de vergoeding voor levering van zaken en diensten tussentijds aan te passen aan de door hem verwachte kosten, onder meer in een geval als bedoeld in artikel 18.7.
18.9 Ingeval de levering van gas, elektriciteit, warmte en/of (warm) water tot de door Verhuurder verzorgde levering van zaken en diensten behoort, kan Verhuurder na overleg met Huurder de wijze van het bepalen van het verbruik en daaraan gekoppeld Huurders aandeel in de kosten van het verbruik aanpassen, waarbij individuele bemetering om het daadwerkelijk verbruik per gebruiker zichtbaar te maken in ieder geval is toegestaan
18.10 Wordt het verbruik van gas, elektriciteit, warmte en/of (warm) water bepaald aan de hand van verbruiksmeters en ontstaat wegens niet of onjuist functioneren van deze meters een geschil over Huurders aandeel in de kosten van verbruik, dan wordt dit aandeel vastgesteld door een door Verhuurder geraadpleegd bedrijf dat in het meten en vaststellen van afgenomen gas, elektriciteit, warmte en/of (warm) water is gespecialiseerd. Dit geldt eveneens bij beschadiging, vernietiging of fraude met betrekking tot de meters, onverminderd alle andere rechten die Verhuurder in dat geval tegenover Huurder heeft, zoals het recht op herstel of vernieuwing van de meters en vergoeding van geleden schade.
18.11 Verhuurder is, behoudens in geval van een toerekenbare ernstige tekortkoming van Verhuurder, niet aansprakelijk voor enige schade die het gevolg is van het niet functioneren dan wel de niet behoorlijke levering van zaken en diensten. Evenmin zal Huurder in dergelijke gevallen aanspraak kunnen maken op huurprijsvermindering.

Omzetbelasting
19.1 Indien Huurder het gehuurde niet (meer) gebruikt of laat gebruiken voor prestaties die recht geven op aftrek van omzetbelasting en daardoor de uitzondering op de vrijstelling van afdracht van omzetbelasting over de huur wordt beëindigd, is Huurder niet langer omzetbelasting over de huurprijs aan Verhuurder c.q. diens rechtsopvolger(s) verschuldigd, doch dan is Huurder met ingang van de datum waarop die beëindiging van kracht wordt, naast de huurprijs in plaats van omzetbelasting een zodanige afzonderlijke vergoeding aan Verhuurder c.q. diens rechtsopvolger(s) verschuldigd dat deze volledig wordt gecompenseerd voor:
a. de als gevolg van het beëindigen van de optie voor Verhuurder c.q. diens rechtsopvolger(s) niet (langer) aftrekbare omzetbelasting op de exploitatiekosten van het gehuurde of investeringen daarin;
b. de omzetbelasting die Verhuurder c.q. diens rechtsopvolger(s) als gevolg van het beëindigen van de optie wegens herrekening als bedoeld in artikel 15, lid 4 van de Wet op de omzetbelasting 1968 of herziening als bedoeld in de artikelen 11 tot en met 13 van de Uitvoeringsbeschikking omzetbelasting 1968 aan de Belastingdienst moet betalen;
c. alle overige schade die Verhuurder c.q. diens rechtsopvolger(s) door het beëindigen van de optie lijdt.
19.2 Het door Verhuurder c.q. diens rechtsopvolger(s), door het beëindigen van de optie (als bedoeld in artikel 19.1) te lijden financiële nadeel wordt door Huurder aan Verhuurder c.q. diens rechtsopvolger(s) voldaan steeds gelijktijdig met de periodieke huurprijsbetalingen en wordt, met uitzondering van de schade als bedoeld in artikel 19.1 sub a, zo mogelijk door middel van een annuïteit, gelijkelijk verdeeld over de resterende duur van de lopende huurperiode, doch is terstond, volledig en ineens van Huurder opeisbaar als de huurovereenkomst om welke reden dan ook tussentijds wordt beëindigd.
19.3 Het in artikel 19.1 sub b gestelde is niet van toepassing indien bij het sluiten van de onderhavige huurovereenkomst de herzieningsperiode voor de aftrek van voorbelasting ter zake van het gehuurde is verstreken.
19.4 Wanneer zich een situatie als bedoeld in artikel 19.1 voordoet, zal Verhuurder c.q. diens rechtsopvolger(s) aan Huurder berichten welke bedragen door Verhuurder c.q. diens rechtsopvolger(s) aan de Belastingdienst moeten worden betaald en inzicht geven in de overige schade als bedoeld in artikel 19.1 sub c. Verhuurder c.q. diens rechtsopvolger(s) zal zijn medewerking verlenen indien Huurder de opgave van Verhuurder c.q. diens rechtsopvolger(s) wil laten controleren door een onafhankelijke registeraccountant. De kosten hiervan zijn voor rekening van Huurder.
19.5 Ingeval in enig boekjaar niet is voldaan aan het gebruik of laten gebruiken van het gehuurde voor doeleinden als weergegeven in artikel 4.3 van de huurovereenkomst, stelt Huurder de Verhuurder c.q. diens rechtsopvolger(s) binnen vier weken na afloop van het desbetreffende boekjaar door middel van een door hem (Huurder) ondertekende verklaring hiervan in kennis. Binnen dezelfde termijn zendt Huurder een afschrift van die verklaring aan de Belastingdienst.
19.6 Indien Huurder niet voldoet aan de informatieverplichting als bedoeld in artikel 19.5 en/of niet voldoet aan de verplichting tot ingebruikname als bedoeld in artikel 19.8, of achteraf blijkt dat Huurder van een onjuist uitgangspunt is uitgegaan en Verhuurder c.q. diens rechtsopvolger(s) daardoor naar achteraf blijkt ten onrechte omzetbelasting over de huurprijs in rekening heeft gebracht, is Huurder in verzuim en is

Verhuurder c.q. diens rechtsopvolger gerechtigd het daardoor ontstane financiële nadeel op Huurder te verhalen. Dit nadeel betreft de volledige ter zake door Verhuurder c.q. diens rechtsopvolger(s) alsnog aan de Belastingdienst verschuldigde omzetbelasting vermeerderd met rente, eventuele boetes, alsmede verdere kosten en schade. Het in dit lid gestelde voorziet in een schadevergoedingsregeling voor het geval de optie met terugwerkende kracht mocht worden beëindigd, zulks naast de in artikel 19.1 weergegeven regeling. De extra schade die voor Verhuurder c.q. diens rechtsopvolger(s) uit die terugwerkende kracht voortvloeit, is terstond, volledig en ineens van Huurder opeisbaar.
Verhuurder c.q. diens rechtsopvolger(s) zal zijn medewerking verlenen indien Huurder de opgave van deze extra schade van Verhuurder c.q. diens rechtsopvolger(s) wil laten controleren door een onafhankelijke registeraccountant. De kosten hiervan zijn voor rekening van Huurder.
19.7 Het in artikelen 19.1, 19.4 en 19.6 gestelde is eveneens van toepassing indien Verhuurder c.q. diens rechtsopvolger(s) eerst na, al dan niet tussentijdse, beëindiging van de huurovereenkomst wordt geconfronteerd met schade door de beëindiging van de voor partijen geldende optie, welke schade alsdan terstond, volledig en ineens door Verhuurder c.q. diens rechtsopvolger(s), opeisbaar is.
19.8 Onverkort het overigens in deze huurovereenkomst ter zake bepaalde, zal Huurder het gehuurde in elk geval, met toepassing van de optie (als bedoeld in artikel 19.1), in gebruik nemen of in gebruik laten nemen voor het einde van het boekjaar waarin de ingangsdatum als bedoeld in artikel 3.1 van de huurovereenkomst is gelegen.

Overige belastingen, rechten, lasten, heffingen, retributies
20.1 Voor rekening van Huurder komen, ook als Verhuurder daarvoor wordt aangeslagen:
a. de onroerendezaakbelasting ter zake van het feitelijk gebruik van het gehuurde en het feitelijk medegebruik van dienstruimten, algemene ruimten en gemeenschappelijke ruimten pro rata parte;
b. milieuheffingen, waaronder de verontreinigingsheffing oppervlaktewateren en de bijdrage zuiveringskosten afvalwater en iedere andere bijdrage uit hoofde van milieubescherming;
c. baatbelasting of daarmee verwante belastingen of heffingen; zulks voor de helft van het bedrag van de aanslag. Verhuurder zal Huurder tijdig op de hoogte stellen van de ontvangst van een aanslag baatbelasting. Verhuurder zal desgevraagd bezwaar maken tegen de betreffende aanslag en daarbij de bezwaren van Huurder, zo mogelijk, meenemen. Huurder zal aan Verhuurder de helft van de daarmee gemaakte redelijke kosten vergoeden.
d. rioolrecht, respectievelijk rioolbelasting, ter zake van het feitelijk gebruik van het gehuurde en het feitelijk medegebruik van dienstruimten, algemene ruimten en gemeenschappelijke ruimten pro rata parte;
e. overige bestaande of toekomstige belastingen, waaronder mede begrepen belastingen die worden geheven voor voorzieningen in openbaar gebied zoals vlaggenbelasting en reclamebelasting, BIZ-heffing, precariorechten, lasten, overige heffingen en retributies:
- ter zake van het feitelijk gebruik van het gehuurde;
- ter zake van goederen van Huurder;
- die niet geheel of gedeeltelijk zouden zijn geheven of opgelegd, als het gehuurde niet aan Huurder in gebruik zou zijn gegeven.
20.2 Indien de voor rekening van Huurder komende lasten, rechten of belastingen bij Verhuurder worden geïnd, moeten deze door Huurder op eerste verzoek van Verhuurder aan laatstgenoemde binnen 2 maanden na dit verzoek worden voldaan.

Verzekeringen
21.1 Indien in verband met de aard of uitoefening van het beroep of bedrijf van Huurder voor het gehuurde, dan wel het gebouw of complex van gebouwen waarvan het gehuurde deel uitmaakt, een hogere dan normale premie van (brand)verzekering voor opstal of inventaris en goederen aan Verhuurder of andere Huurders van het gebouw of complex van gebouwen waarvan het gehuurde deel uitmaakt in rekening wordt gebracht, zal Huurder het meerdere boven de normale premie aan Verhuurder of die andere Huurders vergoeden.
21.2 Verhuurder en Huurders zijn vrij in de keuze van de verzekeringsmaatschappij, de bepaling van de verzekerde waarde en de beoordeling van de redelijkheid van de verschuldigde premie.
21.3 Onder "normale premie" wordt verstaan de premie die Verhuurder of Huurder, bij een te goeder naam en faam bekend staande assuradeur kan bedingen voor het verzekeren van het gehuurde respectievelijk zijn inventaris en goederen, tegen (brand)risico op het moment direct voorafgaande aan het afsluiten van deze huurovereenkomst, zonder daarbij rekening te houden met de aard van het door Huurder in het gehuurde uit te oefenen bedrijf of beroep, alsmede - gedurende de duur van de huurovereenkomst - elke aanpassing van deze premie, die niet een gevolg is van een verandering van de aard of omvang van het verzekerde risico.

Einde huurovereenkomst of gebruik

22.1 Tenzij schriftelijk anders is overeengekomen zal Huurder het gehuurde bij het einde van de huurovereenkomst of bij het einde van het gebruik van het gehuurde, aan Verhuurder opleveren in de staat die bij aanvang van de huur in het proces-verbaal van oplevering is beschreven, behoudens normale slijtage en veroudering.

22.2 Mocht er bij aanvang van de huur geen proces-verbaal van oplevering zijn opgemaakt, dan wordt het gehuurde geacht, behoudens tegenbewijs door Huurder bij aanvang van de huurovereenkomst te zijn opgeleverd in goed onderhouden staat, zonder gebreken en vrij van schade en dient Huurder het gehuurde, behoudens normale slijtage en veroudering, in die staat aan het einde van de huurovereenkomst aan Verhuurder op te leveren.

Het gestelde in de laatste zin van artikel 7: 224 lid 2 Burgerlijk Wetboek is niet van toepassing.

22.3 Huurder dient in aanvulling op artikel 22.2 het gehuurde aan het einde van de huurovereenkomst leeg en ontruimd, vrij van gebruik en gebruiksrechten, behoorlijk schoongemaakt en onder afgifte van alle sleutels, keycards e.d. aan Verhuurder op te leveren.

22.4 Huurder is verplicht alle zaken die door hem in, aan of op het gehuurde zijn aangebracht of door hem van de voorgaande Huurder of gebruiker zijn overgenomen op eigen kosten te verwijderen, tenzij Verhuurder op enig moment schriftelijk anderszins aangeeft of heeft aangegeven. Voor niet verwijderde zaken is Verhuurder geen vergoeding verschuldigd, tenzij schriftelijk anders overeengekomen.

22.5 Indien Huurder het gebruik van het gehuurde voor het einde van de huurovereenkomst heeft beëindigd, is Verhuurder gerechtigd, zich op kosten van Huurder toegang tot het gehuurde te verschaffen en zich in het bezit daarvan te stellen, zonder dat dit een gebrek oplevert.

22.6 Alle zaken waarvan Huurder kennelijk afstand heeft gedaan door deze in het gehuurde achter te laten bij het daadwerkelijk verlaten van het gehuurde, kunnen door Verhuurder, naar Verhuurders inzicht, zonder enige aansprakelijkheid zijnerzijds, op kosten van Huurder worden verwijderd, verkocht en/of vernietigd.

22.7 Tijdig voor het einde van de huurovereenkomst of het gebruik, dient het gehuurde door partijen gezamenlijk te worden geïnspecteerd. Van deze inspectie wordt door partijen een rapport opgemaakt, waarin de bevindingen ten aanzien van de staat van het gehuurde worden vastgelegd. Tevens wordt in dit rapport vastgelegd welke werkzaamheden ter zake van de bij de inspectie noodzakelijk gebleken reparaties en ten laste van Huurder komend achterstallig onderhoud, nog voor rekening van Huurder dienen te worden uitgevoerd alsmede de wijze waarop en de termijn waarbinnen dit zal dienen te geschieden.

22.8 Indien Huurder of Verhuurder, na daartoe deugdelijk in de gelegenheid te zijn gesteld middels een aangetekende brief, niet binnen redelijke termijn meewerkt aan de inspectie en/of de vastlegging van de bevindingen en afspraken in het inspectierapport, is de partij die op vastlegging aandringt bevoegd de inspectie buiten aanwezigheid van de nalatige partij uit te voeren en het rapport bindend voor partijen vast te stellen en onverwijld een exemplaar van dit rapport ter hand stellen.

22.9 Huurder is gehouden de door hem op basis van het inspectierapport uit te voeren werkzaamheden binnen de in het rapport vastgelegde - of nader tussen partijen overeengekomen - termijn op een deugdelijke wijze uit te voeren c.q. te doen uitvoeren. Indien Huurder geheel of gedeeltelijk nalatig blijft in de nakoming van zijn uit het rapport voortvloeiende verplichtingen, is Verhuurder gerechtigd zelf deze werkzaamheden te laten uitvoeren en de daaraan verbonden kosten op Huurder te verhalen onverminderd de aanspraak van Verhuurder op vergoeding van de verdere schade en kosten.

22.10 Over de tijd die met het herstel is gemoeid, gerekend vanaf de datum van het einde van de huurovereenkomst, is Huurder aan Verhuurder een bedrag verschuldigd, berekend naar de laatst geldende huurprijs en vergoeding voor bijkomende levering van zaken en diensten, onverminderd Verhuurders aanspraak op vergoeding van de verdere schade en redelijke kosten.

Betalingen

23.1 De betaling van de huurprijs en van al hetgeen verder krachtens deze huurovereenkomst is verschuldigd, zal uiterlijk op de vervaldata in wettig Nederlands betaalmiddel – zonder opschorting, aftrek of verrekening met een vordering welke Huurder op Verhuurder heeft- geschieden door storting dan wel overschrijving op een door Verhuurder op te geven rekening. Huurder kan alleen dan verrekenen als de vordering door de rechter is vastgesteld.

Dit laat onverlet de bevoegdheid van Huurder om gebreken zelf te verhelpen en de redelijke kosten daarvan in mindering te brengen op de huur indien Verhuurder met het verhelpen daarvan in verzuim is. Het staat Verhuurder vrij door middel van schriftelijke opgave aan Huurder wijziging aan te brengen in de plaats of wijze van betaling. Verhuurder is gerechtigd te bepalen op welke openstaande vordering uit de huurovereenkomst een door hem van Huurder ontvangen betaling in mindering komt.

23.2 Telkens indien een uit hoofde van de huurovereenkomst door Huurder verschuldigd bedrag niet prompt op de vervaldag is voldaan, verbeurt Huurder aan Verhuurder van rechtswege per kalendermaand vanaf de vervaldag van dat bedrag een direct opeisbare boete van 1% van het verschuldigde per kalendermaand,

waarbij elke ingetreden maand als een volle maand geldt, met een minimum van € 300 per maand. De hiervoor bedoelde boete(rente) is niet verschuldigd indien Huurder voor de in artikel 23.1 genoemde vervaldatum per aangetekende brief een gemotiveerde vordering bij Verhuurder heeft ingediend en Verhuurder binnen 4 weken na ontvangst van deze brief inhoudelijk daarop niet heeft gereageerd.

Zekerheden
24.1 Als waarborg voor de juiste nakoming van zijn verplichtingen uit de huurovereenkomst zal Huurder uiterlijk 2 weken voor ingangsdatum als bedoeld in artikel 3.1 van de huurovereenkomst of zoveel eerder als Verhuurder aangeeft een bankgarantie afgeven in overeenstemming met een door Verhuurder aangegeven model ter grootte van een in de huurovereenkomst weergegeven bedrag dan wel waarborgsom storten op een door Verhuurder opgegeven bankrekening. Deze bankgarantie dan wel waarborgsom dient mede te gelden voor de verlengingen van de huurovereenkomst inclusief wijzigingen daarvan en dient geldig te blijven tot tenminste zes maanden na de datum waarop het gehuurde feitelijk is ontruimd en tevens de huurovereenkomst is beëindigd. Bovendien dient deze bankgarantie dan wel waarborgsom te gelden voor de rechtsopvolger(s) van Verhuurder.
24.2 Als de bankgarantie dan wel waarborgsom is aangesproken en (deels) uitbetaald, zal Huurder op eerste verzoek van Verhuurder zorgen voor een nieuwe bankgarantie dan wel waarborgsom, die voldoet aan het gestelde in artikelen 24.1, 24.3 en 24.4 tot het bedrag dat direct voorafgaande aan het moment dat de bankgarantie dan wel waarborgsom werd aangesproken, van toepassing was.
24.3 Huurder is verplicht om, na opwaartse aanpassing van de betalingsverplichting als genoemd in artikel 4.8 van de huurovereenkomst van totaal 15% of meer op eerste verzoek van Verhuurder terstond een nieuwe bankgarantie te doen afgeven dan wel als het een waarborgsom betreft bij te storten tot een bedrag aangepast aan de nieuwe betalingsverplichting.
24.4 Indien de waarborgsom niet rechtsgeldig aangesproken is door Verhuurder dient Verhuurder na beëindiging van de huurovereenkomst de waarborgsom dan wel restant van de waarborgsom terug te storten op een door Huurder op te geven bankrekening uiterlijk zes maanden na einde huurovereenkomst. Indien de bankgarantie niet rechtsgeldig aangesproken is door Verhuurder dient Verhuurder na beëindiging van de huurovereenkomst de bankgarantie terug te sturen naar een door Huurder op te geven adres uiterlijk zes maanden na einde huurovereenkomst.
24.5 Voor andere zekerheden gelden artikelen 24.1 tot en met 24.4 voor zover van toepassing.

Hoofdelijkheid
25.1 Indien verscheidene (natuurlijke of rechts-)personen zich als Huurder hebben verbonden, zijn deze steeds hoofdelijk en ieder voor het geheel jegens Verhuurder aansprakelijk voor alle uit de huurovereenkomst voortvloeiende verbintenissen.
Uitstel van betaling of kwijtschelding door Verhuurder aan een der Huurders of een aanbod daartoe, betreft alleen die Huurder.
25.2 De verbintenissen uit de huurovereenkomst zijn, ook wat erfgenamen en rechtverkrijgenden van Huurder betreft, hoofdelijk.

Niet tijdige beschikbaarheid
26.1 Bij het niet beschikbaar zijn van het gehuurde op de ingangsdatum als bedoeld in artikel 3.1 van de huurovereenkomst, doordat het gehuurde niet tijdig gereed is gekomen, doordat de vorige gebruiker het gehuurde niet tijdig heeft ontruimd of doordat Verhuurder de door hem te verzorgen vergunningen van overheidswege nog niet heeft verkregen, is Huurder tot de datum waarop het gehuurde hem ter beschikking staat geen huurprijs en geen servicekosten verschuldigd en schuiven ook zijn overige verplichtingen en de overeengekomen termijnen dienovereenkomstig op.
26.2 Verhuurder is niet aansprakelijk voor de uit de vertraging voortvloeiende schade voor Huurder, tenzij hem ter zake een toerekenbare tekortkoming kan worden verweten.
26.3 Onder een toerekenbare tekortkoming als bedoeld in artikel 26.2 wordt mede verstaan de situatie dat Verhuurder zich niet inspant om het gehuurde zo spoedig mogelijk alsnog aan Huurder ter beschikking te stellen.
26.4 Huurder kan geen ontbinding van de huurovereenkomst vorderen, tenzij de te late oplevering veroorzaakt is door een toerekenbare ernstige tekortkoming van Verhuurder en het op grond van de redelijkheid en billijkheid voor Huurder onaanvaardbaar is dat de huurovereenkomst ongewijzigd in stand blijft en Verhuurder niet tegemoet komt aan de gerechtvaardigde belangen van Huurder.

Appartementsrecht
27.1 Indien het gebouw of complex van gebouwen waarvan het gehuurde deel uitmaakt, is of wordt gesplitst in appartementsrechten, zal Huurder de uit de splitsingsakte en reglementen voortvloeiende voorschriften

omtrent het gebruik inachtnemen. Hetzelfde geldt indien het gebouw of complex van gebouwen eigendom is of wordt van een coöperatie. Het moeten naleven van die voorschriften levert geen gebrek op. Verhuurder staat ervoor in dat de hiervoor bedoelde voorschriften die bij het aangaan van de huurovereenkomst gelden, niet strijdig zijn met de huurovereenkomst.
27.2 Verhuurder zal, voor zover dat in zijn vermogen ligt, niet meewerken aan het tot stand brengen van voorschriften die in strijd zijn met de huurovereenkomst.
27.3 Verhuurder draagt er zorg voor dat Huurder in het bezit wordt gesteld van de in artikel 27.1 bedoelde voorschriften omtrent het gebruik.

Kosten, verzuim
28.1 In alle gevallen waarin (Ver)Huurder een sommatie, een ingebrekestelling of een exploot aan (Ver)Huurder doet uitbrengen, of in geval van procedures tegen (Ver)Huurder om deze tot nakoming van de huurovereenkomst of Huurder tot ontruiming te dwingen, is (Ver)Huurder verplicht alle daarvoor gemaakte kosten, zowel in als buiten rechte - met uitzondering van de ingevolge een definitieve rechterlijke beslissing door (Ver)Huurder te betalen proceskosten - aan (Ver)Huurder te voldoen.
De gemaakte redelijke kosten worden tussen partijen bij voorbaat vastgesteld op een bedrag dat als volgt wordt berekend; 15% over de hoofdsom met een maximum van € 25.000 per geval exclusief de griffierechten. Bij een procedure worden de kosten van experts (advocaten, deurwaarders ed.) door de in het ongelijk gestelde partij vergoed.
Artikel 6: 96 Burgerlijk Wetboek leden 4 en 6, waaronder uitdrukkelijk begrepen de verwijzing naar het maximaal te vergoeden bedrag aan buitengerechtelijke kosten, is daarmee tussen partijen niet van toepassing.
28.2 (Ver)Huurder is in verzuim door het enkele verloop van een bepaalde termijn.

Boetebepaling
29 Indien Huurder zich, na door Verhuurder behoorlijk in gebreke te zijn gesteld, niet houdt aan de in de artikelen 5.1, 8, 12.1 en 24.1 opgenomen voorschriften, verbeurt Huurder aan Verhuurder, voor zover geen specifieke boete is overeengekomen, een direct opeisbare boete van minimaal € 250 per kalenderdag voor elke kalenderdag dat Huurder in verzuim is. Het vorenstaande laat onverlet de bevoegdheid van Verhuurder om gebruik te maken van zijn overige rechten, waaronder het recht op nakoming en het recht op volledige schadevergoeding voor zover de geleden schade de verbeurde boete overtreft.

Wet Bescherming Persoonsgegevens
30 Indien Huurder een natuurlijk persoon is, verstrekt Huurder bij het aangaan van deze huurovereenkomst, door ondertekening daarvan, toestemming aan Verhuurder en aan de beheerder om de persoonsgegevens van Huurder in een bestand op te nemen / te verwerken.

Domicilie
31.1 Vanaf de ingangsdatum als bedoeld in artikel 3.1 van de huurovereenkomst worden alle mededelingen van Verhuurder aan Huurder in verband met de uitvoering van de huurovereenkomst, gericht aan het adres van het gehuurde.
31.2 Huurder verplicht zich in geval Huurder zijn bedrijf daadwerkelijk niet meer in het gehuurde uitoefent, Verhuurder daarvan terstond schriftelijk in kennis te stellen onder opgave van een nieuw domicilie.
31.3 Voor het geval Huurder het gehuurde verlaat zonder opgave van een nieuw domicilie aan Verhuurder, geldt het adres van het gehuurde als domicilie van Huurder.

Klachten
32. Huurder zal klachten en wensen schriftelijk indienen. In dringende gevallen zal dit mondeling kunnen geschieden. In dergelijke gevallen zal Huurder de klacht of wens zo spoedig mogelijk schriftelijk bevestigen.

Slotbepaling
33 Indien een deel van de huurovereenkomst of deze algemene bepalingen nietig of vernietigbaar is, dan laat dit de geldigheid van het overige deel van de huurovereenkomst en deze algemene bepalingen onverlet. In plaats van het vernietigde of nietige deel geldt alsdan, overeenkomstig het bepaalde in artikel 3: 42 Burgerlijk Wetboek, als overeengekomen, hetgeen partijen overeengekomen zouden zijn, indien zij de nietigheid of vernietigbaarheid gekend zouden hebben.