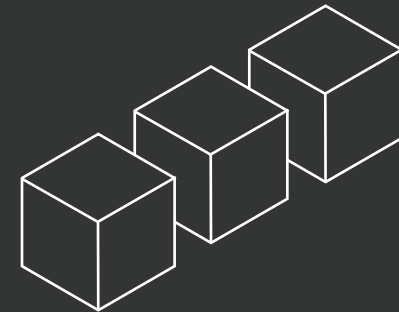


GUIDELINES FOR DESIGNING BLOCKCHAIN BASED BIKE-SHARING SERVICES

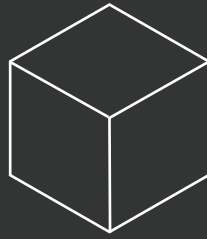
D.B. de Witt

Master thesis Strategic Product Design / Integrated Product Design | TU Delft



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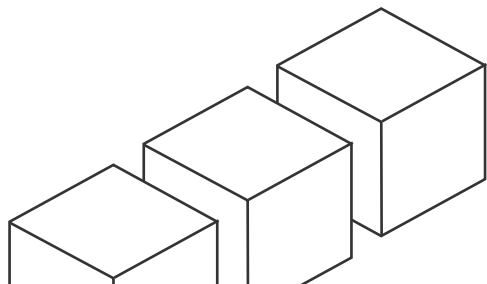
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0.1 Preface

Hereby I present to you my graduation thesis for the Master Strategic Product Design (SPD) and the Master Integrated Product Design (IPD) from Delft University of Technology. This report is the final result of a project done in the past 8 months.

In these 8 months I got the opportunity to dive into the world of Blockchain and explore how this technology could influence the Circular Economy and especially bike-sharing. With all the lessons learned from this project, I feel that it has changed my vision on what the future might hold based on the radical changes that Blockchain technology could potentially make. Therefore I am eager to see how this technology will develop in the years to come and I would be happy to contribute more to this Blockchain community. For this, I hope that this Thesis could be a first useful, yet small, contribution to this future.

This project was done in collaboration with the company Kryha, where I worked every week. During this period I got the opportunity to explore the complex world of Blockchain technology with the help of a company that is an absolute front-runner in this field. With their help, I managed to learn and understand the possibilities of this technology and find a new way to apply it to something as tangible as bike-sharing. However, this company did not only support me with my thesis, they also definitely made me feel like I was a part of their team and included me in all their employee activities. I am very grateful for the warm welcome and all the support that I received from all my colleagues at Kryha and I hope that my work will help them in the future as well.



Alexander, I would especially like to thank you for all your support, feedback, and all the meetings we had in which you helped me to clarify my ideas whenever I got lost in my own fuzzy work.

During this project, there were several times where I struggled with defining the right direction for the project. Luckily, I had a very good support team from the University to help me with creating structure and being more critical to my own ideas. Also, they showed me new opportunities and helped me with identifying my blind spots.

Emilia, Thank you for your support and feedback during the project. You really helped me with structurizing this thesis and I really appreciate the fact that you were always available for a meeting whenever I needed one.

Jacky, Thank you for helping me to be more critical at my work. Your feedback during our team meetings have definitely increased the quality of this thesis.

Furthermore, I could not have completed this project without the support from my friends and family who were always there for me when I needed them.

I hope you will read this thesis and create new insights based on my work.

All the best,

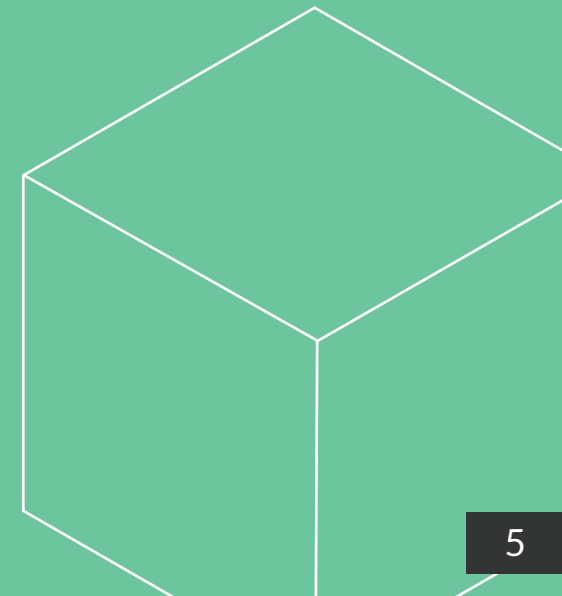
David de Witt

A handwritten signature in green ink, appearing to read 'David de Witt', with a stylized, looping flourish at the end.

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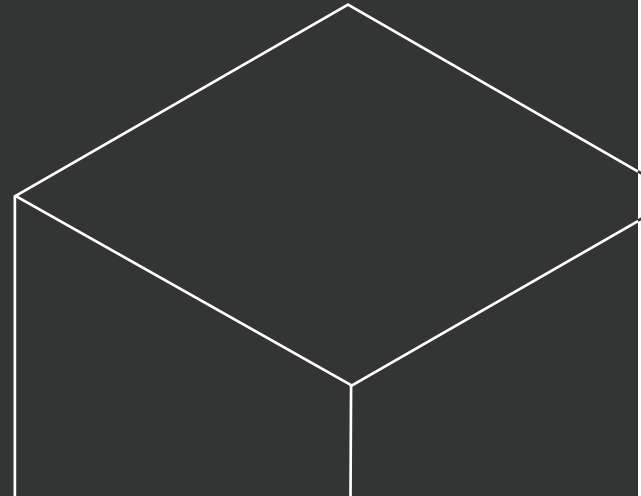
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1.



1. Executive Summary

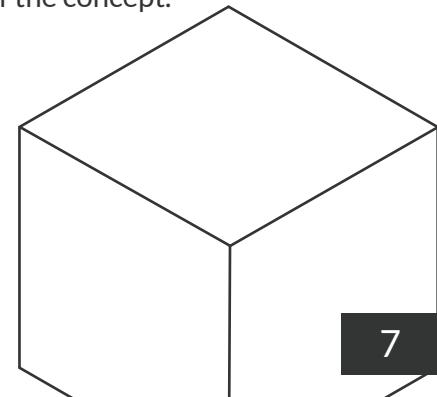
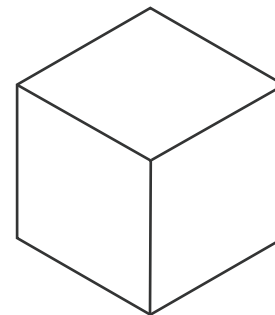
Due to the increased use of finite resources on this planet, there is a growing need for a more circular use of products (Wautelet, 2018). For this, the Circular Economy is focusing on designing circular business processes that utilize resources more efficiently and reduces the amount of waste. One way to do this is via asset-sharing services (Ellen Macarthur Foundation, 2019). However, asset-sharing services face several challenges regarding trust and governance (Ma et al., 2018). Blockchain technology could provide a solution to these challenges by providing a decentralized platform that provides secure peer-to-peer transaction possibilities (Huckle et al., 2016). Nevertheless, Blockchain technology currently is still reaching for maturity meaning, there are almost no use-cases which illustrate how Blockchain can contribute to asset-sharing services in practice. To learn how to implement and create Blockchain based asset-sharing services, more use-cases and design tools are desired.

One asset-sharing service that has gained global popularity in recent years can be seen in bike-sharing (Shaheen et al., 2010). To help (future) bike-sharing companies to design bike-sharing systems that utilize Blockchain-based IoT technology and show how these technologies can contribute to asset-sharing services, this thesis proposes a concept design tool in the form of guidelines. These guidelines can be used to create an ecosystem for a potential bike-sharing service and identify what role Blockchain could play in this service. By implementing Blockchain in bike-sharing services, governance issues of a central party can be avoided. Due to the security of the system and the automation possibilities, the level of trust needed for this system can be reduced as well. Therefore, by using these guidelines, new bike-sharing concepts can be developed and implemented to boost the Circular Economy.

Since there are no use-cases yet available, which could help with creating these guidelines, a use-case was designed for a new Blockchain-based bike-sharing system. For this, a use-case was built around a Blockchain-based bicycle lock called "Lockchain". The Lockchain is a combined project from Blockchain studio Kryha, IoT R&D company TWTG, and the bike-

company X.bike. These companies are developing this lock as a means to reduce the number of bikes in the city of Amsterdam by enabling peer-to-peer bike-sharing. In Amsterdam, there is a rising number of (unused) bikes which lead to parking and mobility problems (Kryha, 2017). (P2P) Bike-sharing has the potential to reduce the number of bikes that are standing still by increasing the usage of bikes. However, due to regulations and failed bike-sharing services, a peer-to-peer bike-sharing system as envisioned by these three companies would not be feasible or viable. Therefore, for the use-case, a new Blockchain-based circular bike-sharing concept, called Rebicycle, was designed which utilizes the Lockchain.

For the design of this use-case and for the guidelines, literature research was done on the challenges of Circular Economy, asset-sharing and bike-sharing. Also, literature research was done for finding technological solutions for these challenges that IoT and Blockchain can offer. Then, for the design of the Lockchain use-case, the context of the bike problem in Amsterdam was further researched by analyzing reports provided by the municipality, interviews with a bike refurbishing company, and via a market analysis. From this research, the design requirements were formed for the Lockchain use-case. With the help of several design tools, the Rebicycle concept was created. The Rebicycle bike-sharing system is a Decentralized Autonomous Organisation (DAO) that utilizes refurbished bicycles and provides these to the citizens of Amsterdam for free. To evaluate the concept of Rebicycle, several actors from the ecosystem were interviewed to determine the feasibility and desirability of concept. At last, a cost analysis was made for the viability of the concept.





2. Introduction



2.1 Reasons for this project

Ever since the first industrial revolution 150 years ago, the industrial economy has been dominated by a one-way model of production and consumption in which goods are manufactured from raw materials, sold, used, and then destroyed or discarded as waste. The amount of raw materials on this planet, however, is limited. In the face of a rising global population and the associated growing resource consumption and negative environmental impacts, it becomes increasingly apparent that continuing with this linear one-way production model is not an option for a sustainable future (Wautelet, 2018). Because of this, several schools of thought have been working on the idea of a Circular Economy for the past few decades (Ellen Macarthur Foundation, 2019). The main focus of the Circular Economy is to use resources more efficiently and reduce negative environmental impact through the design of a circular business system in which resources can be reused, reduced or recycled. In recent years, this philosophy has been getting more traction in the business landscape and society leading to the design of more sustainable business systems. (Blomsma & Brennan, 2017).

As a part of this shift organisations and platforms that enable asset-sharing services have emerged forming a sharing economy. Asset-sharing is one way of using resources more efficiently since the resources used for the asset can be used by multiple parties whenever the owner of the asset does not use it. This reduces the number of assets needed for the number of parties using it (Hamari et al., 2016). Asset-sharing concepts, however, face several challenges regarding responsibility, trust, and governance (Ma et al. 2018). Nevertheless, with the development of recent technologies, some of these challenges can be solved. For instance, the implementation of the Internet of Things (IoT) technology has proven to be successful as an enabler of asset-sharing services (Ellen Macarthur Foundation, 2016). The ability to connect assets with the internet, establishes possibilities to trace, monitor and activate the asset while also collecting usage data (Ganapati & Reddick, 2018). The effectiveness of using IoT in asset-sharing services can be seen in successful examples of asset-sharing companies such as Zipcar (Ellen Macarthur Foundation, 2016).

Another emerging technology that can have a large impact on the sharing economy is Blockchain (Huckle et al., 2018). Blockchain is a distributed ledger technology that records transactions of value in a decentralized manner. Blockchain technology has the potential to decentralize an asset-sharing platform (e.g. Uber, AirBNB etc.) providing a truly peer-to-peer (P2P) asset-sharing service without the need of a third-party actor. In this way, Blockchain has the potential to make asset-sharing services more efficient and less expensive. For instance, a Blockchain-based Uber-like platform could be used for all transactions done from the Uber-driver to the Uber-client leaving out the need for the Uber-company to act as an intermediary between the parties. Furthermore, Blockchain technology could provide trustless and autonomous transactions of value between parties in the sharing system (Ellen MacArthur Foundation, 2016). When combining this technology with connected hardware via IoT, Blockchain has the potential to create a decentralized P2P asset-sharing platform in which all assets are connected (Huckle et al, 2018).

So, these technologies have the potential to be advantageous to asset-sharing services. Since asset-sharing is a part of the Circular Economy philosophy, these technologies are indirectly capable of contributing to a more Circular Economy. However, due to the immaturity of Blockchain technology, the combination of these technologies has not been used on a large scale yet in practice. Because of this, there are little to no case studies available that illustrate how these two technologies could deal with the challenges of asset-sharing in practice and how these technologies could be implemented. Also, there are no frameworks or tools that could specifically be used for designing these kinds of systems. In other words, there are insufficient guidelines or examples that could be used for designing asset-sharing systems that make use of Blockchain and IoT. In order to speed up the implementation of these asset-sharing systems, knowing how to design a system that tackles the challenges it faces with Blockchain and IoT is desired.

A specific case of asset-sharing can be seen in bike-sharing (Figure 1). Bike-sharing makes efficient use of the resources needed for creating the bikes since the same bicycle is being used by multiple users. Also, bike-sharing provides a CO2 neutral mobility option making it a more sustainable form of transport in cities while also actively reducing the required amount of bikes in a city (Zhang et al., 2015). This form of asset-sharing has been around since 1966 but has only been successful since the implementation of digital information systems in the past decades (shaheen et al., 2017). Due to technological advancements of the Internet of Things, bike-sharing has gained global popularity. However, even though there are numerous of successful bike-sharing initiatives at this moment, these endeavours struggle with the same challenges as other asset-sharing services. This means that Blockchain has the potential to contribute to overcoming these challenges in bike-sharing services as well.

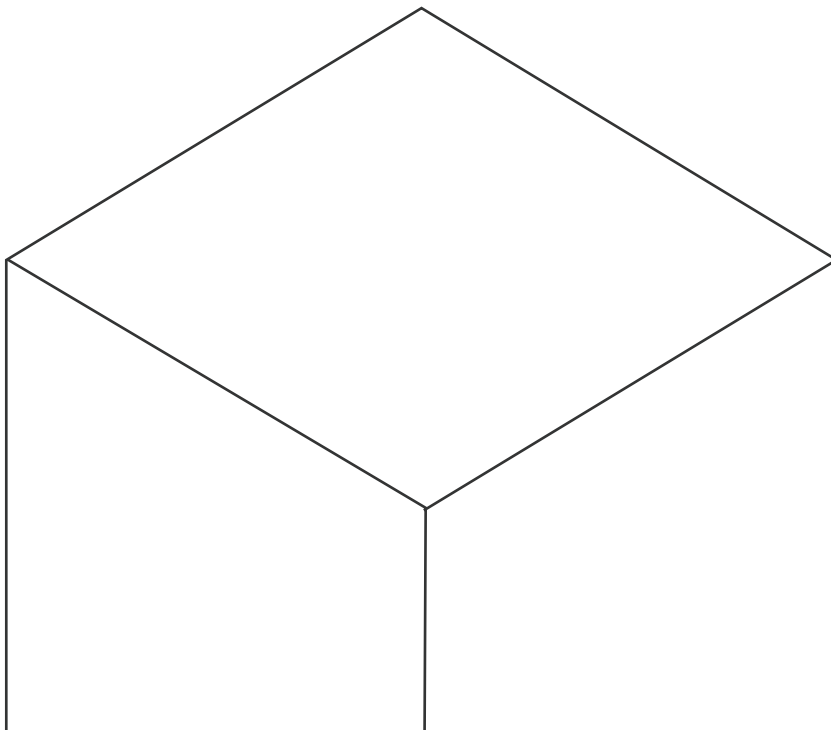
Figure1. Docked bike-sharing bikes (George, 2012)



2.2 The goal of this project

The overall aim of this graduation project is to establish guidelines that can be used for designing and implementing bike-sharing systems in which Blockchain and IoT are used as enabling technologies. These guidelines are meant for current bike-sharing services and new bike-sharing services for helping them to further develop and discover the potential of using Blockchain and IoT in their operations as a solution to several challenges they face. This could open up new opportunities for bike-sharing which stimulates the Circular Economy.

In order to create these guidelines, a case study is analyzed to learn what is required to design such a system. Due to the lack of an implemented use-case to study, a bike-sharing service is designed to identify which challenges bike-sharing systems must overcome and how Blockchain and IoT can solve these challenges. The final guidelines are developed by reflecting upon the design process and results of this case study. For the design of the case study, the case of the Lockchain project is used.



2.3 The Lockchain case

Blockchain studio Kryha and IoT hardware developer TWTG acknowledge the potential of using IoT and Blockchain in asset-sharing systems by creating a combined project called the Lockchain. They created this project to research the potential of combining these two technologies and learn how it could be implemented for contributing to a Circular Economy via asset-sharing in a desirable, feasible and viable way. This means that the combination of the two technologies is contributing to a desired result while being both technically feasible and economically viable.

The Lockchain is a connected bicycle lock that works with Blockchain technology. This lock enables bike owners to share their bikes with other peers without having to deal with intermediary costs for a third party. This means that all payments could be made between peers on a decentralized platform directly which is more efficient and less costly. Such a lock has the potential to be used for increasing the utilization of bikes in crowded cities by allowing the owners to rent out their bikes rather than stalling them (Kryha, 2018). Within the city of Amsterdam are numerous bikes that are rarely used by their owners (Kryha, 2017). These bikes are from a Circular Economy perspective, a waste of resources. Therefore, renting out the bikes present in Amsterdam would be a more circular solution.

Moreover, due to this large number of bikes, most bike parking spaces are occupied causing impediments due to inconvenient bike placements. With a growing number of bikes in Amsterdam, this is becoming a big problem (van der Lof, 2017). If the bicycles present in Amsterdam would be used more, the resources used to create the bikes would be utilized more efficiently and bike parking places would be less crowded. Therefore, the municipality of Amsterdam sees that peer-to-peer bike-sharing would be a fitting solution (Kryha, 2017).

2.4 Structure of the report

In recent years, several bike-sharing companies have emerged in Amsterdam but without any success in solving the bike problems. The Netherlands Enterprise Agency (in Dutch: Rijksdienst Voor Ondernemend Nederland) therefore, provided funding for the Lockchain project to further explore the possibilities of using a decentralized locking system for enabling peer-to-peer bike-sharing. Although the principle of peer-to-peer bike-sharing is clear for this project, the concept around how this lock could be implemented and used to solve the bike problem in Amsterdam is not yet defined. So, for the Lockchain project, it is still unclear how this lock would be used in practice and what this peer-to-peer system would require in order to solve this bike problem. Therefore, the context in which the Lockchain could be used to contribute to the bike problem should be designed.

In figure 2, the structure of the report is visualized. First, the literature research that was done can be read. From the literature research the next step is to read about the methodology that was used for the design of the use-case and the guidelines. The results of the use of these methods, will be found after that in the results chapter. In this chapter, the use-case final concept will be explained. Based on the research questions and the results, a discussion was written after the results. From this discussion the final guidelines for the design of Blockchain based bike-sharing services were created. At last this thesis ends with a conclusion and reflection.

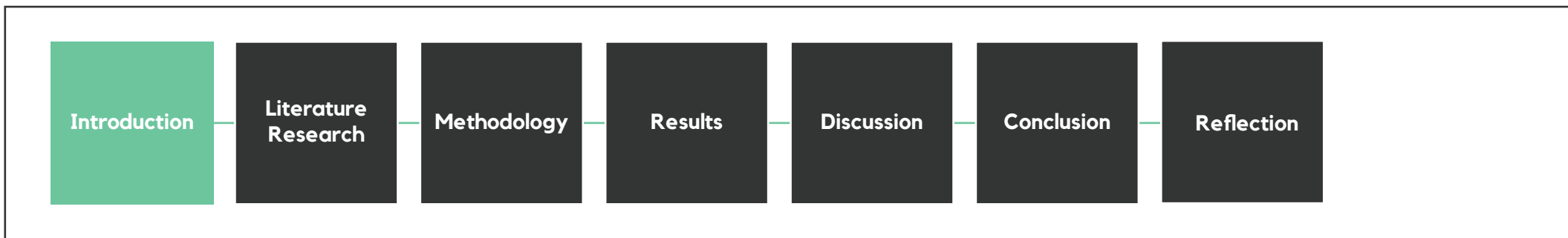
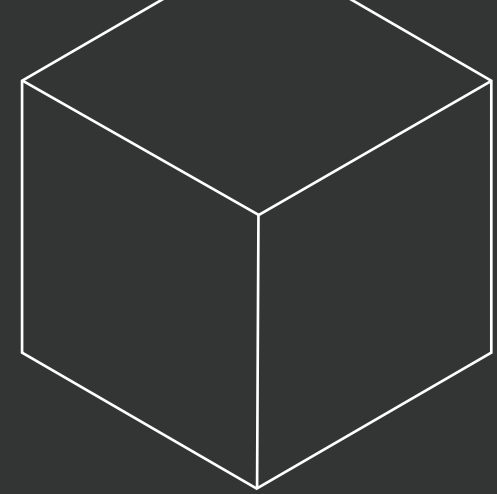
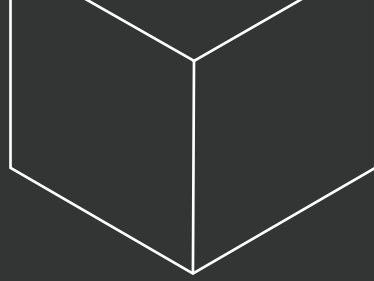
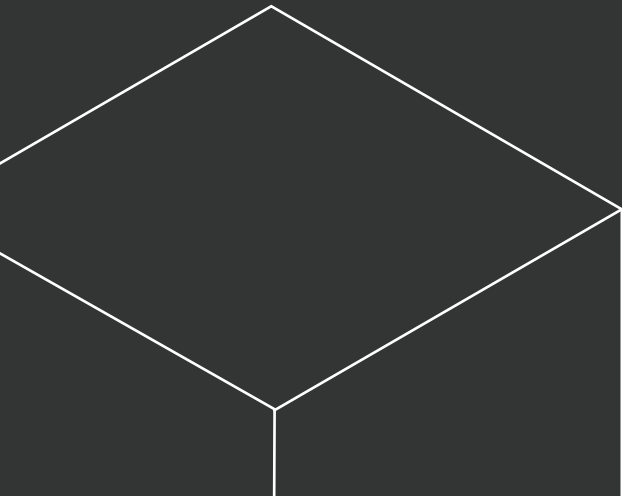


Figure 2. The structure of the report



3. Literature Research

In this chapter, the research fields that are central to this thesis will be introduced via a literature research. The literature research will be divided up into three parts. The first part will explain more about: The Circular Economy (CE), Asset-sharing and Bike-sharing. The second part of the literature analysis, will focus on the technological solutions which the Internet of Things (IoT) and Blockchain can offer. For this, it is important to understand what each of these technologies entails and how they interact with each other in order to understand the reasoning behind this project.



3.1 The problem context

In this part, the context of the problem which this thesis aims to solve is discussed. Starting with the Circular Economy (section 3.1.1), this concept will be explained to demonstrate what the CE holds and what barriers are holding back the implementation of the CE. The CE is quite a broad concept, therefore this thesis will only focus on a specific part of the CE. For this, the role of the asset-sharing within the Circular Economy will be discussed and also which challenges the sharing economy faces (section 3.1.2). It is important to understand the challenges in order to see how IoT or Blockchain could be used to overcome these challenges. Even though some of the challenges of asset-sharing are the same for various types of assets, to limit the scope bike-sharing was chosen as the researched form of asset-sharing and will also be further explored in this chapter (section 3.1.3).

3.1.1 The Circular Economy (CE)

3.1.1.1 What is the CE?

In the past few decades, the global population of humans has grown exponentially with predictions saying that the world will reach a total population of 9.8 billion by the year 2050 (“World population projected to reach” 2017). Also, since the start of the industrial revolution, humanity has increased the harvesting of natural resources tremendously due to economic and technological developments. Because of this, the need for resources and materials has never been bigger. Furthermore, with the large consumption of resources, a huge amount of waste is generated each year. Every year this number is increasing and it is estimated that it will reach 2.2 billion tonnes of waste by 2025 (Hoornweg & BhadaTata, 2012). The resources on this planet, however, are limited and the huge amount of consumption/waste is the cause of multiple major environmental issues (Nag, 2005). Therefore, it is clear that the way

resources are used and waste is produced, must change in order to provide a more sustainable future. This clearly illustrates the problems that were the cause of the creation of the Circular Economy (CE) concept.

So what is the CE? A simple explanation of the CE concept is that the CE is the process of maintaining materials in use instead of simply disposing them. This process helps to close the loop of materials for a product life cycle, and thus they can be used again for new products as well (Ritzén & Sandström, 2017). Although the idea for a Circular Economy can be traced back to the 1970s, the term was first used by D.W. Pearce and R. K.Turner (1990). They used the phrase to illustrate a circular economic model which was based upon the hypothesis that there is an extensive interdependence between the economy and the environment (Wautelet, 2018). However, over the past decades, several other concepts such as Cradle-2-Cradle (McDonough & Braungart, 2010), Performance economy (Stahel, 2010) and Industrial ecology (By et al., 1995) have refined the idea for the CE as well with new perspectives for how to reach a more sustainable future (Ellen MacArthur Foundation, 2019). Each of these philosophies has different approaches but contributes to the same goal: To maintain the value of resources as long as possible within the economy and to minimize waste (economicscircular, 2019). Therefore, it can be said that the CE is used as an umbrella term for multiple sustainable ideologies with no universal definition of the concept (Blomsma & Brennan, 2017).

Nevertheless, in recent years, a more unified idea about the CE has emerged. In 2012 the Ellen MacArthur Foundation published their work “Towards a Circular Economy” in which they illustrated how the Circular Economy could open up business opportunities that are worth billions (Ellen MacArthur Foundation, 2012). With their publication, they have been able to generate traction within the business world for the concept of the CE. They managed to create more awareness for the CE in the business landscape and increase the acceptance within companies for embracing this concept for their own operations.

embracing this concept for their own operations. The foundation managed to do so by making the ideology of the CE more tangible for companies and show them how the CE could be beneficial (Wautelet, 2018). The Ellen MacArthur Foundation sees the CE as a model that is “restorative and regenerative by design and aims to keep products, components, and materials at their highest utility and value at all times. It is a positive development cycle that preserves and enhances natural capital, optimizes resource yields, and minimizes system risks” (Ellen Macarthur Foundation, 2012).” They state that the CE model is based on 3 key principles:

1. Regenerate natural systems
2. Keep products and materials in use
3. Design out waste and pollution

The model of the Ellen MacArthur Foundation shows different ways that contribute to these three principles. The model is inspired by the 3R concept of Reduce, Reuse and Recycle. This concept has been used by multiple authors that were associated with the CE concept (Ranta et al. 2018). Within this concept, reduce stands for the strategy of reducing the resources needed for a product. Reuse is aimed at reusing products again by different actors from the same market and with recycle is aimed at modifying waste materials for new products. (Ranta et al. 2018).

Figure 3. “The phases of the Circular Economy” (Iberdrola.com, 2019)



3.1.1.2 Barriers to implementing the CE

It is clear that the implementation of CE is urgent and luckily the concept of the CE is getting more popular in the business landscape. However, the transformation from the linear economy to a circular seems to stumble upon several barriers. As Ritzén & Sandström (2017) explain, five barriers exist in the change from a linear to a Circular Economy. The first barrier is found in the financial aspect. To implement circular operations, the costs of aspects such as logistics of old material, storage and redesigning can be too expensive for firms and lower their profitability. Also, the number of customers that would prefer to buy a recycled product than a new product is low due to the perceived relation between new products and high quality. (Kumar & Suganya, 2019).

Two other barriers companies may face, are found in the structure and operations of the organization. Implementing circular operations within a company requires more cooperation from multiple departments to work together meaning there is a bigger need for good communication and clear responsibility distribution. Also, infrastructure and supply-chain management need to be reorganized in a more circular way. This requires involvement of the entire ecosystem of the supply chain both internally and externally. This is challenging for large corporations. The fourth barrier is an attitudinal problem. Managers that do not see the value of the circular changes might not want to adapt, and with that, avoid the risks of the changes. At last, there is a technological barrier in play. Companies might need to redesign their products to be more circular and other production methods might not be feasible to implement.

From another perspective, a challenge of the CE is the lack of standardized methods to incorporate the CE (Circular Academy, n.d.). The Circular Economy framework does not provide specific criteria to support the transformation or any specific guidelines on how to implement the concept. This is because the implementation of the Circular Economy varies significantly for different products and markets. The need for individualized or sectoral approaches from these companies make it difficult to provide general standardized guidelines (Ellen Macarthur Foundation, 2012). Nevertheless, more case studies are becoming available from which lessons can be learned regarding implementing CE.

3.1.2 Asset-sharing in the CE

3.1.2.1 Why use asset-sharing?

From the model in figure 3 it can be seen that there are various ways to contribute to a circular life cycle of a product. One way of reusing resources can be found in sharing products. By sharing products, fewer products need to be made while the utilization of the product is being maximized. These models also exploit the highest value opportunities within the Circular Economy since the greatest amount of embedded energy and labor is retained within the products (Moigne et al. 2016). The possibilities for utilizing assets more effectively can be seen in the time the asset is not being used. A report from the Ellen MacArthur Foundation (2015) stated that the average car is parked more than 90% of the time and office spaces are unoccupied 30-50% of the time during working hours. By utilizing these cars and office spaces via digital sharing platforms, the resources are being used more efficiently.

The ability to share assets is nothing new. The internet, however, has enabled asset-sharing on a much larger scale and opened up new business opportunities. Companies such as Uber (figure 4) and AirBNB have embraced the potential of asset-sharing and have grown tremendously in the past few years. These platforms can be seen as a part of the sharing economy.

The sharing economy has created a shift in the way products are used. In traditional ways, people would buy a product in order to use it. However, in the sharing economy, products are provided by peers on a digital platform which can be used by other peers on the platform in exchange for money. In this concept, people are paying more for the use of a product than for the ownership of it. For them, the result of using the product is the most important. This shift from ownership to usage only makes the assets more available to a wider public due to the lower price for usage (Hartl et al. 2016). This shift is spreading quickly with more companies adopting this strategy and providing the use of products instead of the product itself (Sinclair, 2017).

Another example of this can be found in the collaborative consumption concept. Collaborative consumption is another form of asset-sharing in which assets are used more efficiently. Within Collaborative consumption, goods are provided via a digital platform by only one party and can be used by clients for a small fee. As is the case with the sharing economy, users now only have to pay for the usage and are not burdened with the responsibilities of ownership of the product. Collaborative consumption can be seen as a reinvention of the traditional renting/lending market through the power of digital technology enhancements that enables to operate on a scale that was not possible before the internet (Moigne et al. 2016). A popular example of Collaborative consumption can be seen in the mobility sector. In recent years, technologies such as the Internet of Things have enabled assets to be connected. Because of this, mobility sharing companies like Mobike and Zipcar have emerged. These companies offer so-called product-service-systems (PSS) that allow them to offer Mobility-as-a-Service (MaaS). These companies are often referred to as MaaS-providers. In a later chapter, PSS and MaaS providers will be further elaborated on.

Figure 4. The Uber app (Siegal, 2017)



3.1.2.2 Governance challenges of asset-sharing

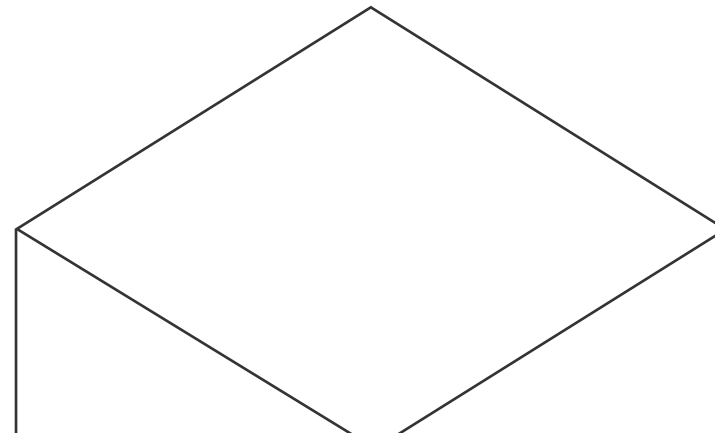
Due to the immaturity of the sharing economy, several governments have found problems with creating laws and legislation for asset-sharing services. A problem they face is based upon the way peers can earn money via these platforms. The sharing economy offers people new ways to make money via P2P transactions in exchange for providing the assets to the users. However, earning a wage via a sharing platform does not give the same legal benefits and does not offer the same protection that employees from a regular company have (Moigne et al. 2016). The central asset-sharing platform often takes high intermediary cuts as revenue, which leaves the provider of the asset with a lower income. It was found that people that earn their wages via a sharing platform make 25% less money as they would do the same job at a company (Moigne et al. 2016).

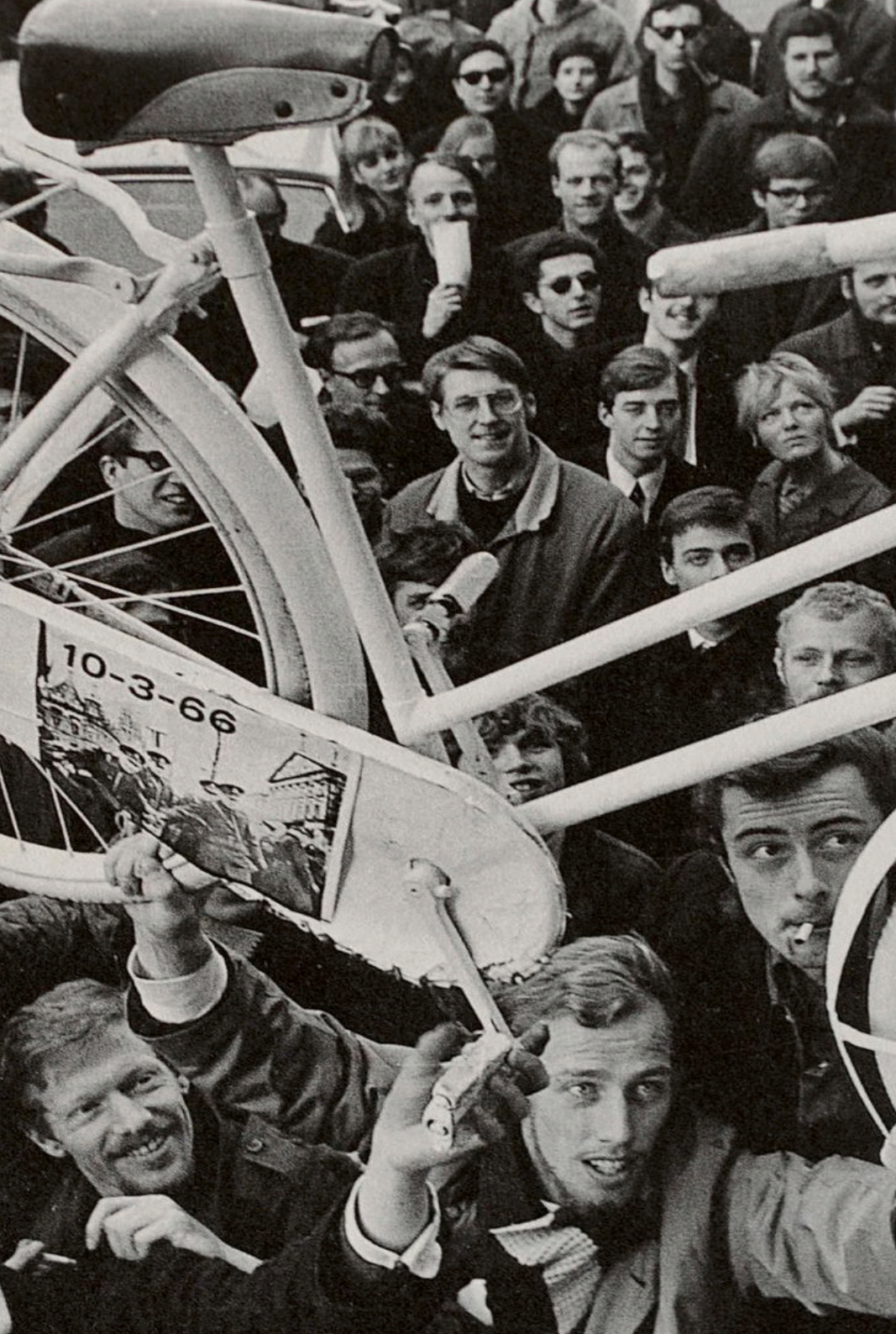
Also, regulations within sharing platforms are often created by a central party that has all the power over the users of the platform. These platforms often have an unfair competitive advantage in the market since they do not have to pay for any assets or employees. This enables them to offer a lower price for similar services. This makes it hard to compete with these platforms which gives them a monopoly position in the market. This monopoly enables these platforms to come with high intermediary costs. (gselabofficial, 2018) Also in many cities, it is not allowed to rent out goods in public places without any legal permission statement from the municipality (Gemeente Amsterdam, 2019). For these reasons, some sharing services such as Uber are illegal in several countries. In order to solve these challenges, proper governance from both the asset-sharing community and the government is required to maintain fair prices and prevent unfair competition (Ganapati & Reddick, 2018).

3.1.2.3 Trust challenges in asset-sharing

In the Sharing economy, sharing goods and services via an internet platform is based on the principle of strangers interacting with each other in a digital environment. Therefore, the presence of trust is a major precondition for successful transactions in the sharing economy. Trust allows humans to form communities, cooperate with each other and even, find solutions that reach beyond plain self-interest (Möhlman & Geissinger, 2018) However, trusting strangers is not in the nature of humans and people. So in order to make sharing systems between strangers successful, sharing economy platforms must tackle the stranger danger idea of all peers involved and create strong trust between all actors (Möhlman & Geissinger, 2018). For this, the design of the platforms must be facilitating trust-building capacities between strangers. To do this, platforms can act as Trusted Third Parties (TTP) or intermediaries, matching the right peers and taking over certain tasks to ensure safe and smooth transactions (Hagiu et al. 2013).

Although the sharing platforms can take away some of the trust issues regarding the interactions between actors, there are also incidents that can happen that are out of control of the parties involved. Incidents such as vandalism or theft might occur in with assets shared in public spaces. The occurrence of these incidents might decrease the willingness to share assets and reduce the level of trust in the system. To control this, sharing platforms must provide proper policies regarding the responsibilities of each actor in the system that are found agreeable by all parties (Conte, 2016).





3.1.3 Bike-sharing

In the previous part about asset-sharing, the essence of asset-sharing in the Circular Economy was discussed. A popular example of asset-sharing can be found in bike-sharing. Bike-sharing is a phenomenon that is being seen all over the world. In the case study discussed in this thesis, Bike-sharing is the form of asset-sharing that will be focused on. Therefore, it is important to understand how bike-sharing works, how bike-sharing has evolved over the years and what challenges bike-sharing faces.

3.1.3.1 Bike-sharing history

In July 1965, the city of Amsterdam started with a revolutionary experiment called “het witte fietsen plan” (figure 5). Within this experiment, the municipality of Amsterdam handed out lock-free-bikes to the citizens of the city to be shared amongst each other. By doing so the city hoped to create a bike-sharing community to improve the mobility in the city and reduce the usage of cars. Although this experiment failed, the idea for bike-sharing was born and became more popular around the world creating multiple generations of bike-sharing initiatives (Shaheen et al., 2018).

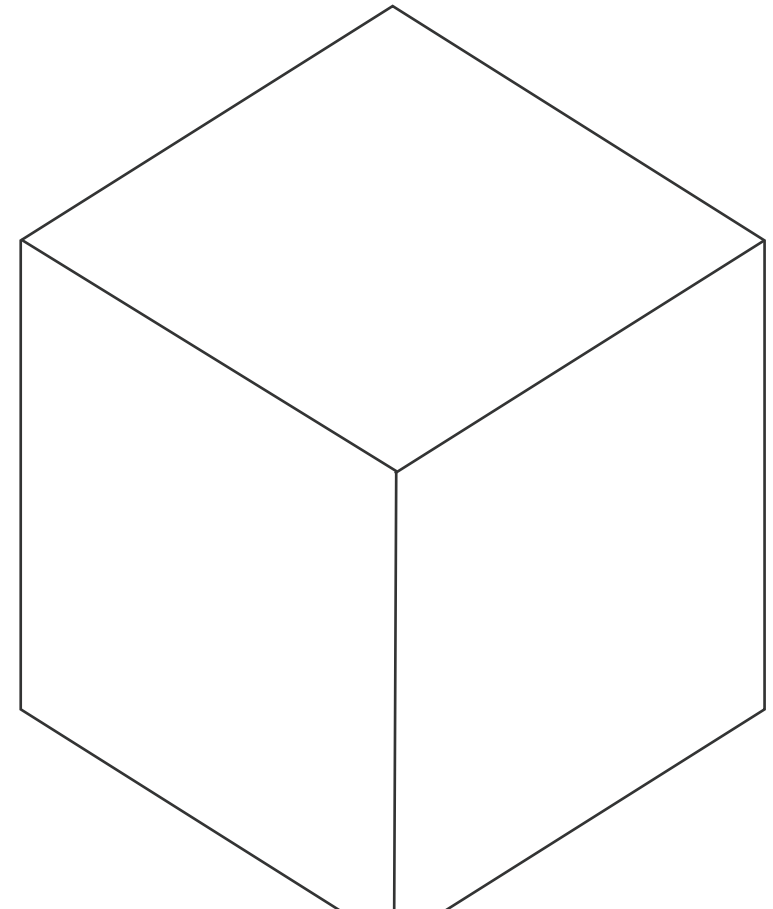
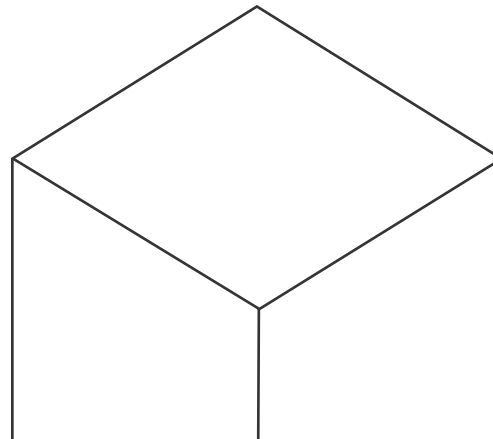
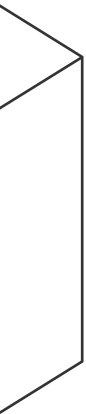
With the White bike Plan being the first generation, the creators did not know how the citizens of the city would handle the bikes and if they were willing to participate in this system. Shortly after the launch of the project, it became clear that the bikes that were given out were got stolen or vandalized. Also, the police confiscated all unintended and unlocked bikes since this would encourage bike theft. Nevertheless, similar free-bike initiatives were launched in Europe but most of them met the same destiny as the initial “Witte fietsen plan”. The bike theft and vandalism problems occurred in all initiatives which showed that these were the first obstacle to tackle in order to create a successful bike-sharing platform (Shaheen et al. 2018).

Figure 5. Giving out white bicycles from “het witte fietsen plan”

The Second generation of bike-sharing wanted to address these problems by creating a coin deposit bike-sharing system with specially designed bikes and bike racks. This was first launched in Copenhagen with 1100 bikes and 200 bike racks. The bikes would still be free to use but in order to unlock the bikes, a small deposit of 20 Kronen needed to be placed in the bike rack. Due to this system, the security of the bikes was improved. However, since there was no time limit, most bikes were gone for a long time before being brought back and some were never returned at all making bike theft once again a reason for failure (Shaheen et al. 2018).

In the third sharing generation, the anonymity of the user of the bike was removed. In order to be able to unlock a bike, the user was required to use his bank card or have a special account that was linked to the user's identity. This enabled the bike-sharing company to know who was using the bikes and who could be held responsible for not returning the bike to one of the special bike racks. Also, the user of the bike would have to pay a small amount of money per usage of the bike to cover some of the costs of the system. This generation was the first one to effectively tackle bike theft and vandalism. Although this generation includes some variety in its execution, all third-generation included: Special bike racks that lock the bike, a digital interface on which the user could verify its identity, More robust designed bikes which do not require a lot of maintenance and payments to use the bike. These bike-sharing systems can be found in almost every continent in the major cities and are successful in their operations (Shaheen et al. 2018).

Based on the success of the third generation, the concept was further developed and more variations were created. Due to technological improvements such as the Internet of Things, bike-sharing platforms became easier to monitor and bikes could be easily tracked. This opened new opportunities such as free-floating bikes which could operate without the help of central bike racks. These systems can be seen as the fourth generation of bike-sharing. In this generation, bike-sharing systems have increased the availability and flexibility of the bike-sharing platform. However, with these features also new problems arrived. In China for instance, where the first free-floating bikes were launched. The bikes were occasionally misplaced and vandalized creating new obstacles for the ideal bike-sharing platform. However, this did not occur in all cities where they were deployed due to creating strict regulations from the municipality (Chen et al, 2018).



Type

Components

Characteristics

	1st generation: free-bike systems	2nd generation: coin-deposit systems	3rd generation: IT-based systems	4th generation: demand-responsive systems
Type				
Components	<ol style="list-style-type: none"> 1. Bicycles 	<ol style="list-style-type: none"> 1. Bicycles 2. Docking stations 	<ol style="list-style-type: none"> 1. Bicycles 2. Docking stations 3. Kiosk or user interface technology 	<ol style="list-style-type: none"> 1. Bicycles 2. Docking stations 3. Kiosk or user interface technology 4. Bicycle distribution system
Characteristics	<ol style="list-style-type: none"> 1. Distinct bicycles (usually by colour) 2. Bicycles located randomly 3. Bicycles unlocked 4. No charge for use 	<ol style="list-style-type: none"> 1. Distinct bicycles (colour or special design) 2. Bicycles located at specific docking stations 3. Bicycles with locks 	<ol style="list-style-type: none"> 1. Distinct bicycles (colour, special design or advertisements) 2. Bicycles located at specific docking stations 3. Bicycles with locks 4. Smart technology is used for bicycle check-in and check-out (smartphones, smartcards) 5. Theft deterrents are used (e.g. members give personal details) 6. Programs are paid for as a membership service 	<ol style="list-style-type: none"> 1. Distinct bicycles 2. Programs may include electric bicycles 3. Specific docking stations that are more efficient (mobile, solar powered, etc.), 4. Improved locking mechanism to deter theft 5. Touch screen kiosks, user interface 6. Bicycle redistribution system 7. Linked to public transit smartcard

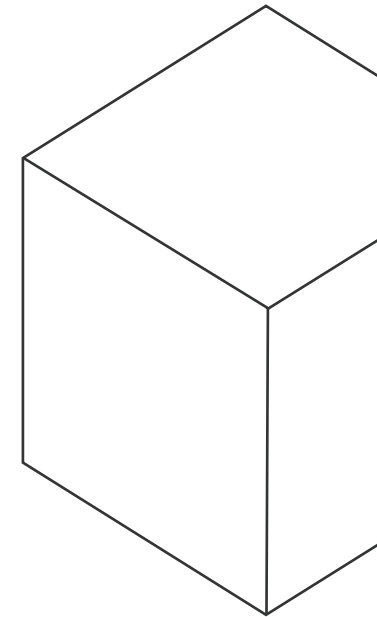


Figure 6. Components and Characteristics of the various bike-sharing generations. (Adapted from Bootsma, 2019)

3.1.3.2 Learnings from history

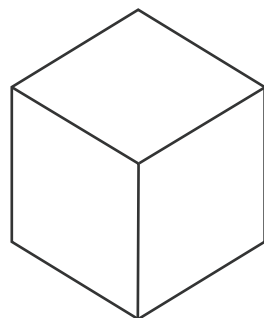
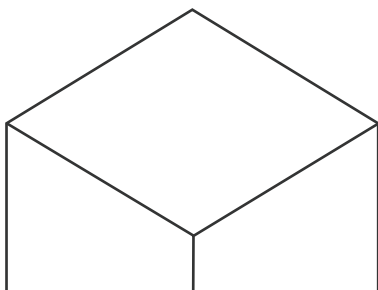
In figure 6 an overview can be seen of all the various bike-sharing generations and what the differences between them are. By analyzing the previous generations of bike-sharing platforms multiple problems of these systems arise and were solved in the later generations. According to Shaheen et al (2018), the following lessons can be learned from all bike-sharing generations until now.

Vandalism & Theft

The main reason for failure in the first generation was a large number of bikes stolen/vandalized (Shaheen et al. 2018). Generation three, however, has shown that this problem was reduced by taking away the anonymity of the user. Due to the possibility to make someone responsible for returning the bike, people tended to be more careful with the bikes. Also, in the newer systems where GPS technology was implemented to track bikes, fewer bikes were lost and abandoned bikes could easily be relocated to a bike rack where it could be used again. Moreover, to counter vandalism, more robust bikes that require less maintenance can be used (Shaheen et al. 2018).

Distribution and Availability

One key element for a successful bike-sharing initiative was stated to be the wide availability of the bikes in the city. In order to prevent bike shortages/overflow, most bike-sharing initiatives have deployed vehicles to collect and relocate bikes throughout the city to maximize the efficiency of the system. By implementing connected sensors into the bike racks, the crowdedness of these racks could be monitored as well making it possible to place them on more strategic places.



Liability

The question of insurance and liability has transformed over time since the anonymity of the system was removed by the digital information systems. Because of this, people could be held responsible for any form of misuse. This caused organizations to collect payments if their assets were mistreated by the users.

Information systems

With the possibility of collecting data in real-time, bike-sharing initiatives have become more efficient and user-friendly. As mentioned above it opened new tracking possibilities and enables the users of the system to be identified. By adding an information system to a bike-sharing service, new types of bike-sharing can be created such as free-float bikes. It enables people to find bikes easier and makes the bikes easier to access. Also, data collected from these platforms could be used for the improvement of the cities mobility. However, collecting data does come with challenges regarding data security and privacy regulations.

Market and Legislation

The legislation of bike-sharing systems has differed between countries and cities since the start of the bike-sharing initiatives. In every city, different rules apply for where the bikes can be parked and in what area the bike-sharing initiatives can operate. Also, the amount of bike-sharing operators that are allowed per city can differ to protect the bike-sharing market from being overcrowded.

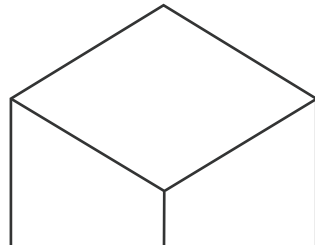
So, from these lessons, it can be that through the evolution of different bike-sharing generations solutions were found to tackle the reasons for failure. These lessons must be taken further into account for designing a new bike-sharing service system. The most important lesson, however, is that the developments in information systems such as innovations like IoT, have the potential to solve and contribute to many challenges of bike-sharing.

3.1.4 Conclusion context research

The context research was scoped down from the CE to bike-sharing. From each level of zooming in several lessons were learned which will be used for the progress of the project. Starting with the CE as a whole, the end goal of every circular project should be to reduce waste and make efficient use of resources. Therefore, while working on the use-case, the result should be aligned with the philosophy of the CE. Secondly, to successfully implement the CE philosophy into a company, several barriers have to be overcome. In this project, these five barriers will be discussed taken into account to see whether Blockchain and IoT are reducing these barriers. At last, although there is a need for standardized methods, these are hard to make companies since they require individualized approaches. To contribute to this, guidelines will be made to offer an extra method for the sector of bike-sharing.

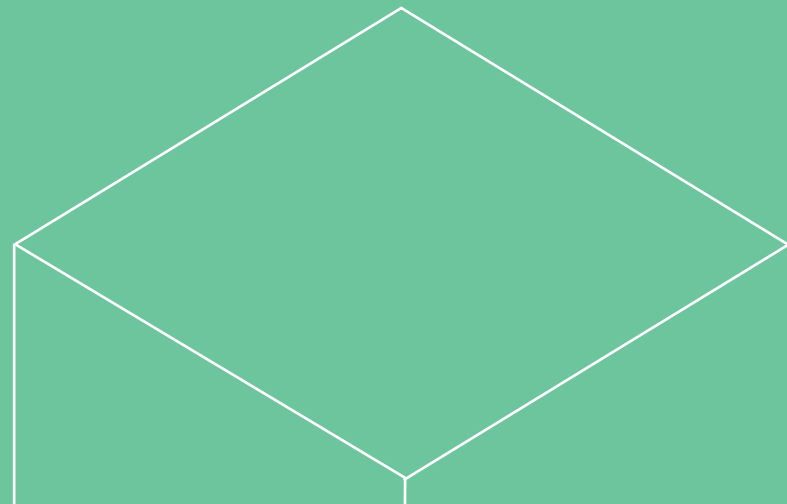
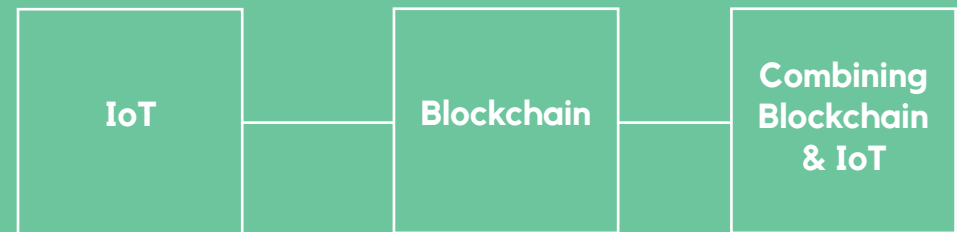
When zooming in at Asset-sharing only, it could be seen that asset-sharing can improve the efficient use of assets by enabling more users to use the asset. However, centralized companies can cause governance challenges in asset-sharing services which have a negative influence on the end user of the asset as well as for the provider of the asset. Furthermore, trust must be present between the end user and asset provider in order to work successfully. Therefore, asset-sharing platforms should be able to provide trust between the users of the asset-sharing platform.

Since asset-sharing is still too broad of a scope, this project will only focus on bike-sharing. From the literature research on bike-sharing it can be seen that bike-sharing has evolved throughout the past few decades. Although bike-sharing has not always been successful, the innovation of implementing digital systems have shown to be able to counter the main reason for failing which is due to vandalism and theft. Overall several lessons could be learned from other bike-sharing services which are to be found in section.



3.2 Technical solutions

With the challenges regarding CE, asset-sharing and bike-sharing in mind, first IoT will be explained to see how this technology can help (section 3.2.1). Secondly, the technology of Blockchain will be further discussed (section 3.2.2). Blockchain, however, is quite complex. Therefore, this technology will only be explained at a functional abstraction level and will only cover relevant topics that are required for the understanding of this project. Once both Blockchain and IoT are discussed, the last part (section 3.2.3) will explore what the result of combining these technologies is.



3.2.1 The Internet of Things (IoT)

In previous chapters, various examples were discussed in which IoT has been mentioned as a possible enabling technology. But what is IoT exactly and how can IoT create value to asset-sharing services? This chapter will dive deeper into this topic and show how IoT has enabled new business models that can be used for asset-sharing.

3.2.1.1 What is the Internet of Things?

The Internet of Things (IoT), also called the Internet of Everything or the Industrial Internet, is a new technology paradigm (Lee & Lee, . 2015). Simply put, the Internet of Things is the possibility of connecting devices to the internet and to each other. This is being envisioned as a global network of machines and devices capable of interacting with each other. For this, devices such as smartphones, coffeemakers and even refrigerators are now provided with connected sensors that enable all kinds of data collection. Via hardware that connects these devices with the internet via broadband, 4G, or wifi, they are able to share this data with other devices. By doing so, other devices can autonomously read this data and use this for their own functionality. The communication between devices enables devices to work together and provide a better user experience. Therefore, it is now widely being used in several markets with endless possibilities.

3.2.1.2 How can IoT add value

In its essence, IoT enables all kinds of offline products to become part of an interconnected system. Because of the wide range of possibilities that are enabled by the connectedness of a product, the way IoT can add value to an offline product can differ. According to Sinclair (2017) there are 4 different ways in which IoT can add value to a product:

1. Make better products
2. Operate products better
3. Support products better
4. Create new products

By letting the products collect transferable data, new functionalities can be added to the product to improve the products itself and so make the product better. For instance, by collecting data from other devices, the product could add more functionalities. These added functionalities can enhance the product's overall performance and might give the product a competitive advantage over non-IoT products (Sinclair, 2017). Also, by analyzing operational data that was provided by an IoT device sensors, the operations of the IoT product can be optimized and made more efficient. This is done by looking at the optimal results of the device. Therefore the product can be operated better. Another way of using IoT is to maintain and support products better. Sensors placed in different parts of complex products could indicate where maintenance would be needed. This offer a better support for the product. This data could also be used to predict when maintenance might be needed in the future. At last, IoT enables a whole new type of product to be made. Products such as smartwatches or smartphones would be useless without their connected capabilities.

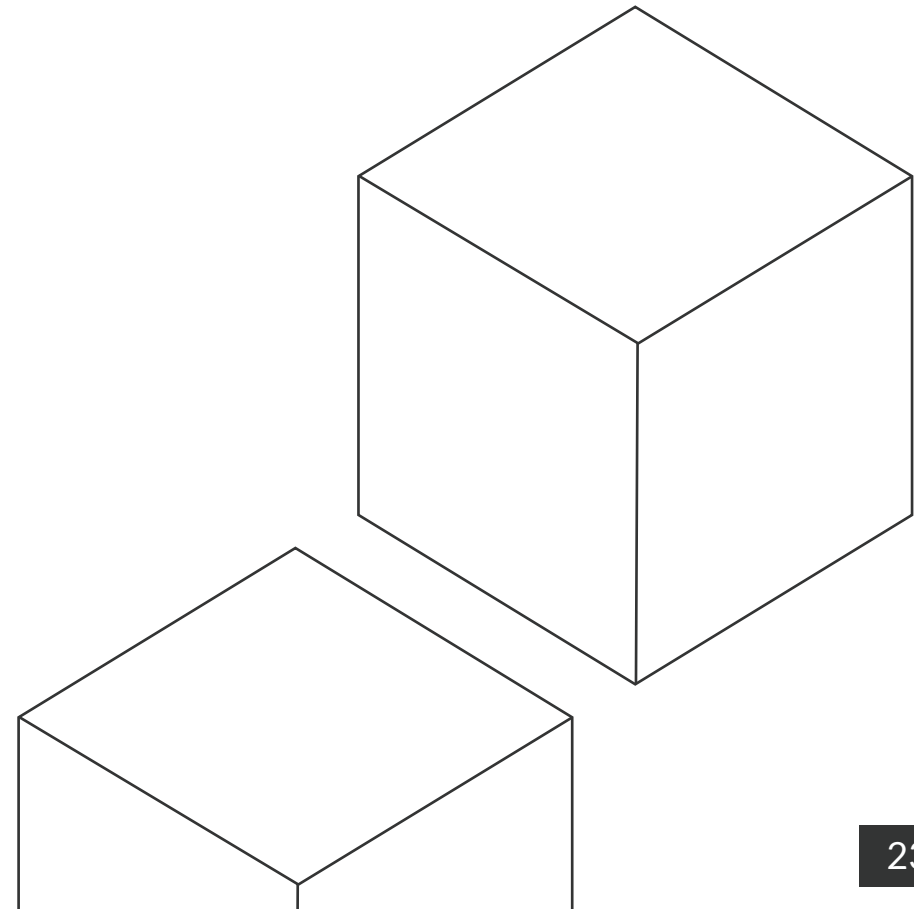
Although these different ways of improving the offline products are already adding value to the product itself, the true value of IoT comes from the interconnectedness of these IoT products. By connecting different IoT products via a network, new IoT ecosystems can be designed in which every actor of the ecosystem is working together to reach for the desired outcome (Sinclair, 2017). But what does an IoT ecosystem contain? An IoT ecosystem can be seen as all the different IoT devices and actors that operate together by communicating with each other to cooperate. When designing new IoT solutions, it is important to know what the relation is to the other actors in the same ecosystem. This will determine which data the IoT solution should be able to collect and what data is needed from the other products to create the desired outcome. The value of IoT can therefore be found in the whole ecosystem of IoT products and the outcomes it provides.

3.2.1.3 IoT for business

As mentioned before in the asset-sharing section (3.1.2), a shift can be seen from ownership to outcome. IoT plays a large role in this shift. It enables products to be monitored, tracked and operated via a digital platform. This creates the ability to trace and control the product which is desired in asset-sharing services. By enabling continuous updates on the whereabouts of the assets, products retrofitted with an IoT device can be shared more easily. IoT does not only open new possibilities for sharing itself, but it also creates new business opportunities. One new trend that emerged due to the IoT, is the existence of Product Service Systems (PSS) (McKinsey, 2018). In PSS, products are provided with sensors that are able to track the usage of the product. These products are not sold but rented out to the users. The users will only pay for the actual usage of the products and not for the product itself. The products, operate as a service for the user. Using products as a service brings along two eco-friendly benefits (Mont, 2002). On one hand, the producers of the product will need to make products that are mean to last since the longer the product lifespan, the more it can be used. On the other hand, as is the case with sharing economy/Collaborative consumption, the same product can be used by multiple parties. The enablement of these PSS are well aligned with the sharing aspect and prolong product lifetime aspect of the CE.

The Product Service Systems that offer products as a service are often referred to as X-as-a-Service (XaaS). One famous example of this is done at Schiphol airport in the Netherlands. This airport is provided with Lighting-as-a-Service (LaaS) by the lightbulb company Philips. By applying this model, it is beneficial for Philips to build light bulbs that last whereas Schiphol does not have to worry about buying new light bulbs since these will be replaced for free by Philips (Phillips, n.d.)

From a business aspect, IoT offers another great advantage: the opportunity to sell data. Since IoT enables products to collect data on the usage of the product, it also creates big data stacks. Especially when sharing the same product with several users, loads of usability data can be collected. The data collected by IoT devices could be very useful for other companies that are interested in consumer behavior. Therefore, IoT product suppliers are able to sell the data collected via their IoT products and make a profit via this way (Sinclair, 2017). This business model, however, does have quite some restrictions regarding the privacy of its users. Due to these heavy regulations, privacy issues have been the center of attention for several IoT producers (Sinclair, 2017).



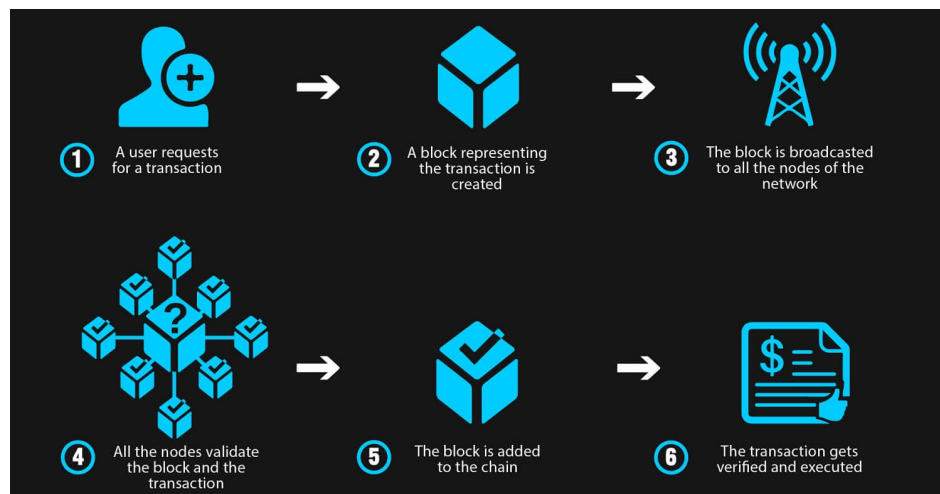
3.2.2 Blockchain

3.2.2.1 A new technology

In the past few years, the term “Blockchain” has grown in popularity and is becoming a buzzword within the field of innovation. Multiple organisations are currently experimenting with Blockchain to see how they can use it for their benefits. Advisory company Gartner, predicts mainstream adoption by companies in various fields of this technology will take place in the next 2-5 years (2019). Therefore this technology is still reaching for it’s potential in the upcoming years and so it is very relevant to dive deeper into what this potential holds.

Blockchain has also caused high expectations in the Circular Economy landscape. According to the Ellen MacArthur Foundation (2016), Blockchain technology could play a significant role in designing CE supply chains while it also enables a more secure and efficient transactions between different actors in a circular ecosystem. Also Blockchain could combine automated sharing platforms with IoT enabling hardware in which assets could be shared (Huckle et al., 2016). But what is Blockchain exactly? How does it work? What can it be used for and how can this technology work together with IoT to contribute to the sharing of assets for a more CE? These questions will be answered in this chapter.

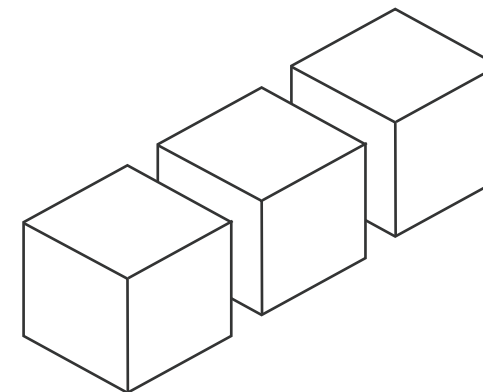
Figure 7. “How does Blockchain work?” (Anwar, 2018)



3.2.2.2 How does Blockchain work?

So, what is Blockchain exactly? Blockchain is a digital infrastructure for exchanging value in a secure and decentralized way. Rather than having one central entity (e.g. a bank) who keeps a record of all ongoing transactions for every involved actor, all actors own a copy of the record. This means that every peer in the system is in possession of all transactions done in the system which makes the system transparent for everyone connected. This is done as a means of security in which the main goal is to ensure that all peers in the ecosystem own the same version of the “truth” which exists of all honest transactions. It basically operates like a digital ledger in which every transaction between users is checked, saved and sent to all connected nodes (peers). However, to be part of this network, it is not required to run a full node unless this is in the design of the chosen Blockchain.

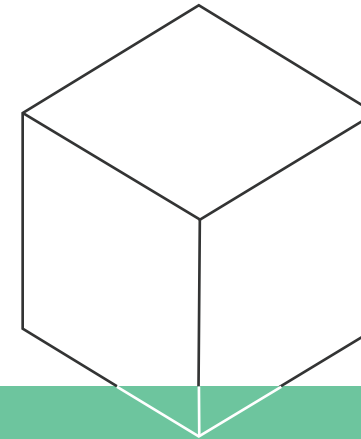
Figure 7 describes how a transaction in Blockchain works. It starts with a node that requests a transaction to be done. This transaction is encrypted in a new block. This new block is broadcast to all nodes in the system for validation. These nodes validate whether the transaction is unique to ensure that no currency is spent twice. If the other nodes accept the new block, the block is added to the existing Blockchain and the transaction is executed. The Blockchain principle consists of three technologies to make this secure exchange possible: **a distributed ledger**, **immutable storage**, and **a consensus algorithm** (Elsden et al., 2018).



The distributed ledger can be explained as a database that enables all nodes of the network to propose and execute transactions. The ledger algorithm is structured as a chain of blocks of which every node in the system has a copy. Each of these blocks contains transactions of data that were requested by the nodes. Each block is provided with a block header that contains a timestamp and a cryptographic hash which is the link to the previous block. This hash is created with a cryptographic algorithm and works as a reference code of the block. The hash of each block is built up from the hashes of previous blocks in combination with its own timestamp and the transactions recorded in the block. (Nakamoto, 2008) Each additional block is propagated to the network of nodes in the system which ensures that every node's copy of the Blockchain is up to date.

The immutable storage is based on the fact that every block in which a transaction is registered links to all previous and future blocks in the chain. By changing the transactions in one block in via one node, all blocks added after that block will no longer be valid. This causes the nodes Blockchain to be seen as malicious. Since all the nodes in the network agree on every block added to the Blockchain, all malicious Blockchains will be replaced with an updated true version. This means that all data in the Blockchain is immutable and no transaction could be replaced unnoticed.

The consensus algorithm verifies that every block added to the Blockchain is valid. This technology is needed to make sure that all transactions remain unique so no user could double-spend cryptocurrencies (See double-spending problem). Every block that is proposed by a node needs to reach for consensus from the other blocks in order to be accepted. By doing so, a shared consensus is reached about the state of the Blockchain (Elsden et al., 2018). This can be done via different consensus protocols. Each consensus protocol tries to incentivize the nodes to check the transaction for uniqueness. By having at least 51 percent (This number might vary in consensus algorithms and configurations of the Blockchain) of all nodes in the network.



Double-spending problem

“For the past few decades, the digital revolution has been defined by the ‘internet of information’, which has democratized the way we communicate around the world by enabling low-cost, massive peer-to-peer communication where everyone is an active participant. However, when I send an email on that internet of information, I am in fact sending ‘a copy’ of that email. That system works well for information, but not for things with some sort of underlying value, which depends on scarcity. Things like money, stocks, bonds, votes, carbon credits, data, intellectual property, and art cannot be reproduced infinitely if we hope to maintain their value. If someone can infinitely copy the \$100 they just sent somewhere, that \$100 suddenly has no value. This is called the double-spend problem.” (Tapescott et al, 2016)

3.2.2.3 What can Blockchain do?

As Swan (2015) describes, Blockchain can become part of the 5th digital paradigm. With the first four paradigms being the mainframe, personal computer, the internet, and mobile/social networking, Blockchain has the potential to work as the economic overlay to what is increasingly becoming a seamlessly connected world of multi-device computing that includes wearable computing and Internet-of-Things (IoT). Due to its trustless and efficient nature, it has the potential to become the seamless economic layer of the entire Web. These properties of Blockchain can be useful for many applications. Werbach (2018) describes that this trustless and efficient nature aspects are important for scenarios in which Blockchain will reach its full potential. He states that Blockchain is best used in situations where the other actors cannot be trusted and where there is a need for more speed and efficiency for transactions between multiple parties.

Trustless exchange

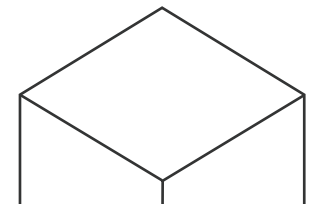
Due to the distributed network and consensus technology, Blockchain could operate without the help of a central trusted third party (i.e. a central bank, law firm). This means that rather than placing trust in a third party, actors in the Blockchain place their trust in the technology (Klein & Prinz, 2018). This creates trustless transactions between different parties. This, however, does not mean the role of trusted third parties will disappear but the use of Blockchain has the potential to change their roles. As Wust & Gervais (2018) state: "In general, using Blockchain only makes sense when multiple mutually mistrusting entities want to interact and change the state of a system and are not willing to agree on an online trusted third party." Also, this could be used as a way to create trust with another party. For instance, If a company feels it is not perceived as trustworthy it could potentially make use of a Blockchain to skip the direct trust relationship building and create trustless transactions between them (Manrique, 2018).

Efficiency

Another result of using Blockchain is the cost reduction for transactions and the efficiency of value transactions with multiple parties. By leaving out a third central party, intermediary costs will not be necessary. These third parties, such as notaries, lawyers, and auctioneers, are being paid for playing the role of a trusted party. By replacing their functions with code, their costly efforts will no longer be needed. Also by cutting out the middleman, transactions can be done instantly and more efficiently reducing the level of bureaucracy. Moreover, due to the peer-to-peer structure in the system, every node is also instantly updated which means all involved parties are always up to date.

3.2.2.4 Relevant Blockchain innovations

Since the release of Nakamoto's white paper on Bitcoin, Blockchain technology has evolved. The first use-case of the Blockchain was to act as a distributed ledger for digital currencies. This generation of Blockchain applications was called Blockchain 1.0. (Unibright.io, 2017). Blockchain 2.0 can be seen as the second stage of the Blockchain evolution. Swan (2015) states: "Blockchain 1.0 is for the decentralization of money and payments, Blockchain 2.0 is used for the decentralization of markets more generally and contemplates the transfer of many other kinds of assets beyond currency using the Blockchain" (Swan, 2015) The creation of Blockchain 2.0 started with the development of Ethereum. Ethereum is another Blockchain that is able to use "smart contracts" to enable the trustless transaction of value between parties and create the automation of transactions. These smart contracts are also the technology behind Dapps (Decentralized Applications) and DAOs (Decentralized Autonomous Organizations) that can work autonomously. Blockchain 3.0 innovations can be categorized as technological improvements of Blockchain 2.0 tackling its limitations while also enabling different applications for Blockchain going beyond currencies and markets (Swan, 2015). So with these innovations being implemented, more and more different possible roles of Blockchain have emerged.



Smart Contracts explained

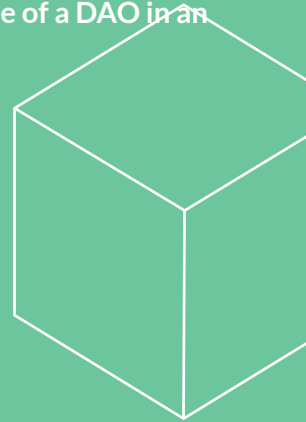
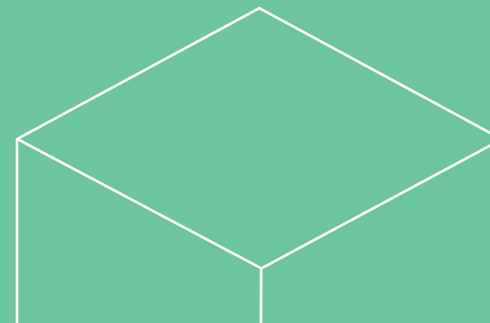
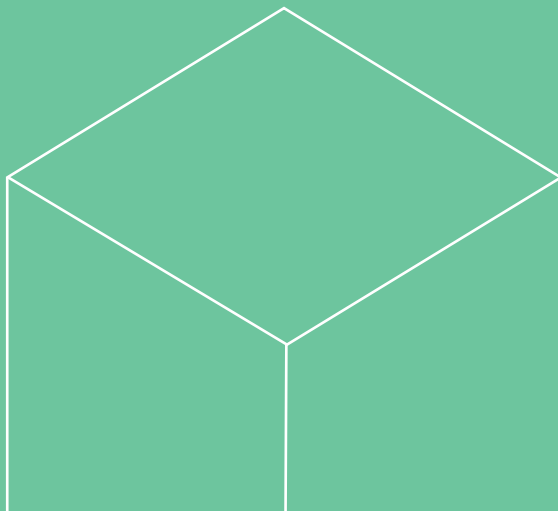
An ordinary contract can be seen as an agreement between two or more parties in which is stated what these parties can or can not do for a certain exchange. With these traditional contracts, each party must trust the other party to keep up its side of the agreement. Smart contracts can be seen as the digital version of regular contracts. They feature the same kind of agreement which states what is expected from all involved parties in order to execute the transaction between the parties. However, smart contracts are capable of removing the need for trust between parties. Since smart contracts are defined and executed via code, the contracts are discretely and autonomously enforced. This means the contract will only be executed when both parties keep to their end of the deal (Swan, 2015).

Smart contracts have three key properties that distinguish them from regular contracts: autonomy, self-sufficiency and decentralization. First of all, autonomy means that after the smart contract is launched and running, there is no need for an agent to operate or execute the contract. Secondly, smart contracts might be self-sufficient in their ability to collect and maintain resources meaning they are capable of providing services in exchange for power or storage to operate. Third, smart contracts are decentralized. They are distributed and self-executing across network nodes in a P2P system making them immutable and safe from being destroyed (Filipi, 2014).

Dapps and DAO's

Due to the introduction of smart contracts on the ethereum Blockchain, more complicated decentralized applications running Blockchain could be built. These applications are called Dapps (Decentralized Applications). These decentralized applications can create decentralized platforms for value exchanging services and might even replace existing service systems that are controlled by a third party. Most Dapps do require to have 3 properties: A token for transactions, an open-source code that runs autonomously and all improvements to the system must be done via reaching consensus within the whole system (Swan, 2015) An example of a Dapp could be a decentralized version of the Airbnb platform in which no central entity has to be paid in order to use the platform.

However, the opportunities created by smart contracts are not only limited to applications. In fact, whole organizations could be automated by smart contracts. These kinds of organizations are called Decentralized Autonomous Organisations (DAO's). DAO's take away problems which regular companies have to deal with such as hierarchy and governance (Blockchainhub.net, 2019). The way the company operates is determined by the creators of the DAO and programmed in the smart contracts of the DAO. In later chapters, the role of a DAO in an asset-sharing system will be discussed.



Cryptocurrencies

The most well-known use of Blockchain can be found in cryptocurrencies like Bitcoin. Since Blockchain is a distributed ledger that contains immutable information on value transactions, this technology is capable of recording transactions of monetary value as well. Blockchains ability to register digital information to be distributed but not copied, unique cryptographic codes representing a digital currency can be created (Rosic, 2018). Therefore this technology has been used as an enabling technology for the existence of cryptocurrencies. A cryptocurrency is a digital or virtual currency that uses cryptography for security. Unlike fiat currencies like the Euro or the Dollar, it is not issued by any central authority but by a decentralized network of nodes which maintain the cryptocurrencies Blockchain. The most famous example of a cryptocurrency, is the Bitcoin which was also the first cryptocurrency that used Blockchain technology. Currently, there are more than 4000 different cryptocurrencies and this number is still growing. This is due to the fact that everyone is allowed to make their own cryptocurrency which is possible due to Bitcoins open-source protocol which enables new coins to be build on top of the Bitcoin Blockchain. These coins are referred to as Altcoins (alternative Bitcoins). The value of the cryptocurrency, relies on the value that the community of cryptocurrency users gives to the coin (Rosic, 2018). Based on this mutual agreement, cryptocurrencies can be used as a form of currency exchanges.

Cryptocurrencies, can also be used as a form of tokenization. This is used for offline assets that can be registered on the Blockchain by means of a token. This token is than the digital representation of the asset (Aziz, 2019). This means that the token could also represent fiat currencies. The way tokenization is used for fiat currencies can be seen in many mobile applications today. In these applications tokens/coins/credits can be bought with fiat currency via the mobile application store. These tokens can then be used within the mobile applications to unlock new features (Liberbits, 2016).

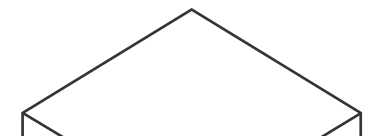
3.2.2.5 Limitations of Blockchain

Although Blockchain enables many different applications, it is still far from perfect. Like all new technologies, it does have many limitations. These Blockchain limitations don't make the technology less revolutionary, but they have raised questions about its efficiency, reliability and sustainability. While looking at the original idea of Blockchain as proposed by Nakamoto, these limitations include scalability, speed, energy consumption and security (Mudrakola, 2018).

Scalability and Speed

Due to Blockchain consensus mechanisms that are performed by every node in the system, the amount of transactions that can be checked is limited. This is because ever check needs a certain amount of time and which slows down the transaction speed if more transactions are demanded. This limits the number of transactions that can be made in a given time. The Ethereum Blockchain, for example, can currently only process about 17 transactions per second whereas Facebook can handle 175,000 requests per second (Raviv, 2018). For the handling of large amounts of data transactions, for instance, this is too slow to be effective. Therefore, in order to make this technology suitable for IoT data transactions, higher transaction speed is required.

Another limitation of Blockchain is the growth of Blockchain itself. Because Blockchain is an immutable distributed chain of blocks, the size of the Blockchain grows at a very rapid pace, and will only grow larger. The Bitcoin Blockchain, for instance, has already passed the size of 200 GB which demands quite a large portion of the node's storage (Blockchain.com, 2019). Scaling with the original Blockchain technology, therefore, has its limitations. However, with Blockchain 3.0 on the rise, more and more new Blockchain technologies have emerged that are able to solve these issues. Another distributed ledger technologies named IoTa is even capable of increasing their transaction speed whenever more nodes are connected to the network though, this technology still needs a few nodes (called permanodes) that are capable of storing the entire Blockchain (Schätz, 2018).



Energy Consumption

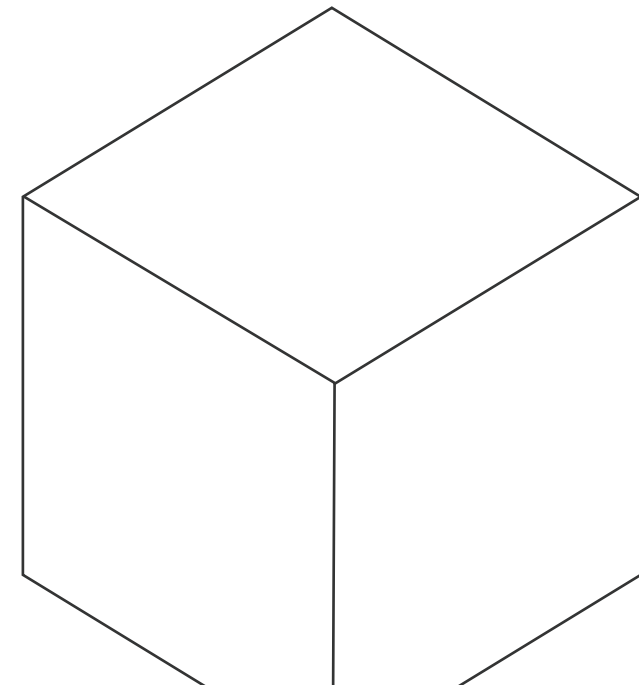
Another major limitation of Blockchain is its energy consumption. The consensus algorithm of Proof-of-Work which is used for Bitcoins for instance, requires a lot of energy to create a new block. Currently, Bitcoin Blockchain technology consumes yearly more energy than the entire country of Kuwait (Bitcoin Energy Consumption Index, 2019). This is of course, highly unsustainable and is not in line with the idea of the CE. Nevertheless, with the coming of other consensus protocols that are less energy demanding by replacing the energy-demanding proof of work puzzles. In Proof-of-Stake consensus for instance, peers can vote for which node will be used to validate the blocks without having to solve a puzzle. Also, with the development of DAG's (Directed Acyclic Graph) and several consensus mechanisms (Proof-of-Stake, Proof-of-Authority), newer generations of Blockchain technology have become less energy-consuming.

Security

In the original design of Blockchain technology, Nakamoto stated that there was one unavoidable security flaw that can affect the integrity of the Blockchain. This has to do with the consensus-protocol. As explained before, if more than half of the computers working as nodes in a Blockchain network validates something then that's considered to be the truth and it has reached consensus. However, if more than half of all nodes would agree on a lie than the lie will be considered as the new truth. This creates the opportunity for malicious nodes to double-spend their cryptocurrencies. This is known as the 51 percent attack and is an unavoidable flaw in the system. Nevertheless, by increasing the size of a Blockchain network, this is very unlikely to happen and makes it way more secure than a central system.

Privacy

Due to the transparency of the Blockchain and the P2P network, every peer in the network is up to date on all transactions that are being made and by which peer. Each peer is identified by its public key. Although the public key of a peer is not automatically linked to the peer's identity, all actions done by that particular public key can be seen by the entire network. When data such as medical records or identity information are stored as transactions, these can become visible for all peers as well which is not desirable. Also, All this information about the transactions done by that public key is immutable and cannot be deleted from the Blockchain. Several international privacy laws, however, state that all information from a user should be deleted if requested (Price, 2019). These privacy issues, however, are currently worked on via concepts such as Zero Knowledge Proof (ZKP), which enables data can be validated and used but is not disclosed by any of the peers (Oscar, 2019). Also, new regulations regarding privacy are being made, these will, due to the immaturity of Blockchain, take some time until they are implemented.



3.2.3 Combining Blockchain and IoT

3.2.3.1 Value of combining Blockchain and IoT

Since Blockchain and IoT are still relatively new technologies, much of their potential still has to be uncovered. However, it has already become clear that the combination of these technologies opens up several new possibilities. As mentioned earlier in this report, Blockchain can be used for all kinds of value transactions, this includes the transactions of data. Data collected by sensors can safely be stored on the Blockchain and be shared with all the nodes of the Blockchain. This quality is quite valuable for IoT based ecosystems in which hundreds of IoT devices are connected. In regular server-client based IoT architectures, it can be quite problematic to synchronize every IoT device separately. Also, servers can be vulnerable to cyber-attacks (e.g. DDoS attacks) and when the server is down, the whole system becomes inoperable. Blockchain solves these problems due to its secure nature and distributed structure. IoT devices that are connected to a Blockchain and running a node will be up to date whenever a new block emerges and are less likely to be hacked. (Huh et al. 2017)

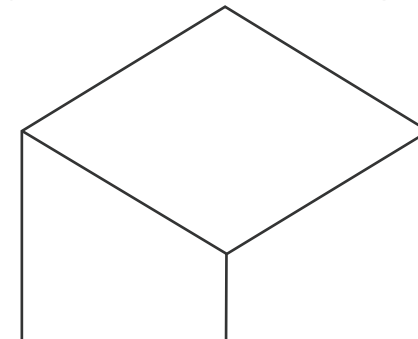
Another strength that comes from combining Blockchain with IoT can be found in the use of smart contracts (Huckle et al. 2016). IoT sensors are able to provide proof with their data that agreements that are stated in a smart contract are met. So if the data from these sensors meet the data required for a certain transaction mentioned in a smart contract, the smart contract will be able to proceed with the transaction or enforce other actions. However, sensors can be tampered with. This means that there is a need for trust in the sensors and sensor operators.

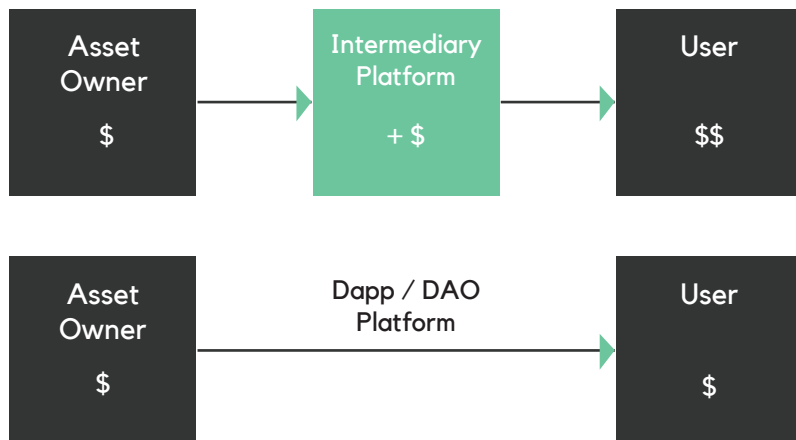
Furthermore, combining IoT with Blockchain can also give a digital identity to offline assets by connecting IoT hardware to the assets. These assets can be registered on a Blockchain to secure and track the asset (Huckle et al. 2016). This means that these IoT connected assets can be monitored and that all interactions with the asset by various users can be monitored as well.

3.2.3.2 Blockchain, IoT and asset-sharing

In the chapter about asset-sharing, several challenges were mentioned. These challenges were revealed by existing asset-sharing platforms such as Uber and AirBNB. However, with the development of Blockchain, some of these challenges can be overcome. The AirBNB and Uber asset-sharing platforms show that these companies operate as an intermediary party. They facilitate the possibility of an agreement between the asset provider and asset user. However, for doing so these companies ask a certain financial compensation in the shape of a percentage of the generated revenue. This makes the use of the asset more expensive and provides fewer benefits for the asset owner. Also, AirBNB and Uber offer little to no responsibility to the providing parties of the platforms. Uber drivers, for instance, do not receive the same social security as regular employees do.

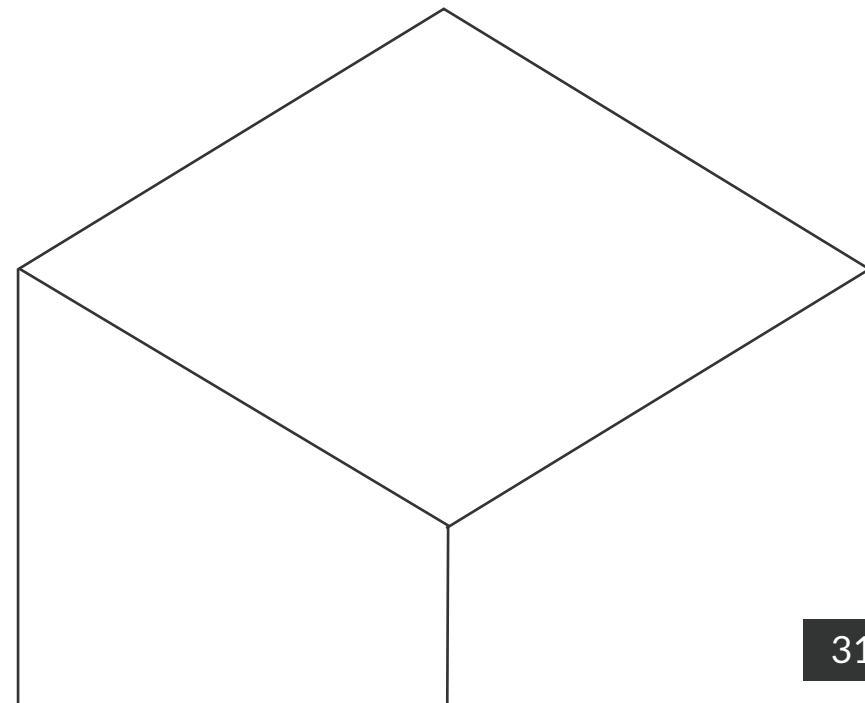
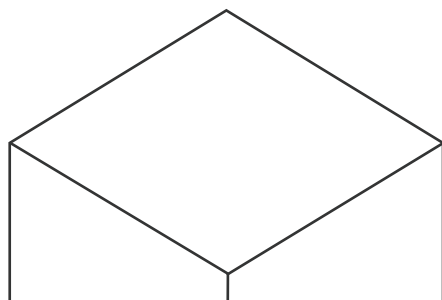
For bike-sharing companies, this role is a bit different. Here the provider of the bike is the company itself meaning that there is no transaction asked for using the companies platform. However, since the company is operating as a central entity, it still is aiming at creating profit which causes a higher usage price for the end-user of the bikes. Therefore, the stimulation of bike-sharing, it would be better to remove the intermediary role of these platforms to enable prices for bike-sharing without transaction costs or a profit margin. This can be done by creating a decentralized platform in which the bike owner and bike user can directly deal with each other. For this, Blockchain is a suitable technology (Huckle et al. 2016). These platforms can even operate as Dapps or DAO's meaning they completely remove the need for a third party (Figure 8).





Another challenge that Blockchain might solve can be found in the trust issues different actors of the P2P network could have. When renting out an asset with a stranger, smart contracts and IoT sensors can guide the trust of the user to trust in the system rather than to trust the stranger. Blockchain makes sure that the transactions done by the renting party are trustworthy and with the help of smart contracts, the owner of the asset can create rules for using the asset. With these rules set in the smart contract, the provider of the asset can make the user liable for misusing the asset. Furthermore, with the help of IoT products, an asset owner can be better informed about the whereabouts of the asset and its user.

Figure 8. Via a Dapp/DAO platform, asset owners can directly do transactions with the user without the help of an expensive intermediary.



3.2.4 Conclusion technology research

Starting with IoT, the most valuable lessons for this project from the research, can be found in the way IoT adds value and how this can influence the business model of an IoT system. By the ability of collecting data, IoT products create the possibility to sell the collected data to a third party. Furthermore, this data can be used for maintaining or improving the products and it can even be used by other devices. These other devices and parties together are part of the total ecosystem of the IoT product. This means the ecosystem of IoT devices plays an important role for designing IoT devices.

Due to the Blockchain research, a better understanding was created on what Blockchain technology is capable of. From this research, it was found that in general Blockchain offers two situations in which it can add value. First, this technology enables decentralized, secure, peer-to-peer transactions that are completely trustless. Therefore, this technology can create trust in situations where multiple untrusted parties share data with one another. Also, Blockchain technology can be used for efficiency gains. Due to the decentralized nature of the technology, no third party is required for managing the data transactions. This reduces the time and costs of transactions being done by various parties. Also, due to the utilization of smart contracts, all kinds of transactions can be automated. This opens up new possibilities for creating fully Decentralized Autonomous Organisations. On the other hand, due to the immaturity of the technology, Blockchain still faces multiple limitations. In order to become widely adopted, these limitations will need to be reduced in the near future.

When combining IoT and Blockchain, it was found that the security of the data could be improved tremendously due to the immutability of the Blockchain caused by the used consensus mechanisms. Also, data collected with the help of an IoT device could be used to trigger smart contracts. This opens up a wide range of possibilities basing transactions on IoT data. In asset-sharing this could be used for creating a decentralized peer-to-peer asset-sharing platform.

3.3 Research questions

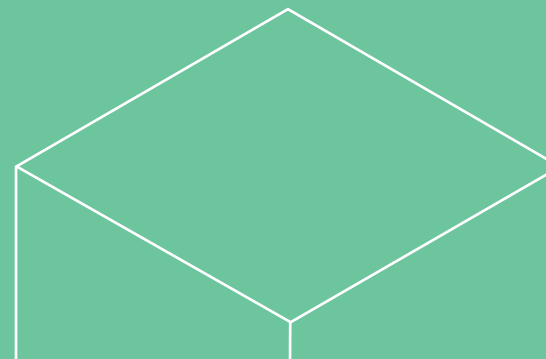
Based upon the findings of the literature research, the research questions which must be answered by this thesis were formulated. These research questions will be answered by the concept of the use-case and by the final design of the guidelines. Furthermore, these research questions will be discussed in the discussion section of this thesis (chapter 7).

How can Blockchain be applied to bike-sharing services to help with overcoming the challenges regarding governance and trust?

- How does Blockchain operate with IoT to solve these challenges?
- How is the role of Blockchain in the bike-sharing service defined?

How can a decentralized Blockchain based bike-sharing service be designed in a desirable, economically viable and technically feasible manner?

- What frameworks or methods could be used for designing a Blockchain based bike-sharing service?
- What are the requirements for a Blockchain-based bike-sharing service?





4. Methodology



In this chapter, the methods used for designing the guidelines for designing Blockchain based bike-sharing services are discussed. For this, first, the process of the project is discussed. For the design of these guidelines, it was decided to look at a use-case to see what is required for building such a service. However, due to the immaturity of Blockchain technology, no relevant use-case was available. Therefore it was decided to design a use-case of new bike-sharing service. For this use-case, the Lockchain project of Kryha, TWTG and X.bike was used. This chapter will show what methods were used to create a use-case for the Lockchain and what was done to create the final guidelines that are presented in chapter 7.



4.1 The process

In order to reach the goal of this graduation project (See section 2.2). A process strategy was determined based on several process methods at the start of this project based on experiences gathered during the two Master's programs of Strategic Product Design and Integrated Product Design. Section 4.1 will elaborate more on what the different steps of this process holds and why they were chosen.

4.1.1 About the process

The chosen process of this thesis was inspired by the design thinking method but several changes were made. These changes were made since building a prototype for the use-case or testing out the working of the use-case were out of the scope of this project. Therefore, the steps of prototyping and testing were replaced by evaluating as a way of validating the feasibility, desirability and viability of the use-case. By evaluating these aspects, the grounding for the guidelines that are based upon this use-case will be stronger and more realistic. Furthermore, since the final design of the guidelines is based upon the process of the use-case design, an extra phase was added called Reflection. During this phase, the guidelines for designing a Blockchain based bike-sharing system were defined by reflecting upon the tools used and analyzed during this project.

So in total, the process can be split up in the following phases: Empathize - define - ideate - evaluate - reflect. The reason for choosing this process comes from the complexity of the topics. In order to be able to design guidelines for using Blockchain technology in a bike-sharing service, a good understanding is needed for understanding both the context of the problems and the technology. The design thinking method starts off with analyzing the context of the problem and empathize with the situation and dives deeper in defining the problem which helps to understand the complexity of the situation while also defining which requirements are needed for the problems that need to be tackled. These first two phases lays the foundation for the ideation phase that follows and with the help of the requirements, the evaluation of the concept can be done. The reflect phase is needed for the design of the guidelines which is done via reflecting on the results and process of the use-case.

4.1.2 The phases

Empathize

The goal of this phase is to create a proper understanding of the problem that this thesis wants to solve. In order to do so, literature research was done in two directions. First, the context of the problem was researched by looking into the challenges of the Circular Economy, Asset-sharing and Bike-sharing. Secondly, the technologies that could offer solutions for these challenges were researched. Starting with the Internet of Things, research was done to see how this technology could add value and how this technology could be combined with Blockchain. In order to do so this Blockchain technology was further explored to see what this technology is capable of and how it operates. In the end of this phase, there is a clear understanding of which challenges were present in bike-sharing services and how these technologies could deal with this.

Define

In the define phase, the requirements for the design of the use-case are developed. The requirements were extracting by researching the context of the problem that are caused by the large number of bikes in Amsterdam which the use-case needed to solve. For this, multiple reports from the municipality of Amsterdam were analyzed and a competitor analysis was performed. Furthermore, the Lockchain itself was further explored to see how this product could be used to solve the bike problem in Amsterdam. The result of this phase is a list of requirements for the design of the use-case.

Ideate

In the Ideation phase, insights from the first two phases were used to combine the problem of the case with the possible solutions that can be offered by the two technologies resulting in several iterations. First, for developing these iterations, several tools that could help with designing a Blockchain and IoT-based bike-sharing service, are analyzed. By using these tools in this phase, a new product-service-system is designed in which Blockchain and IoT act as enabling technologies that could help with fulfilling the requirements that were set up in the define phase.

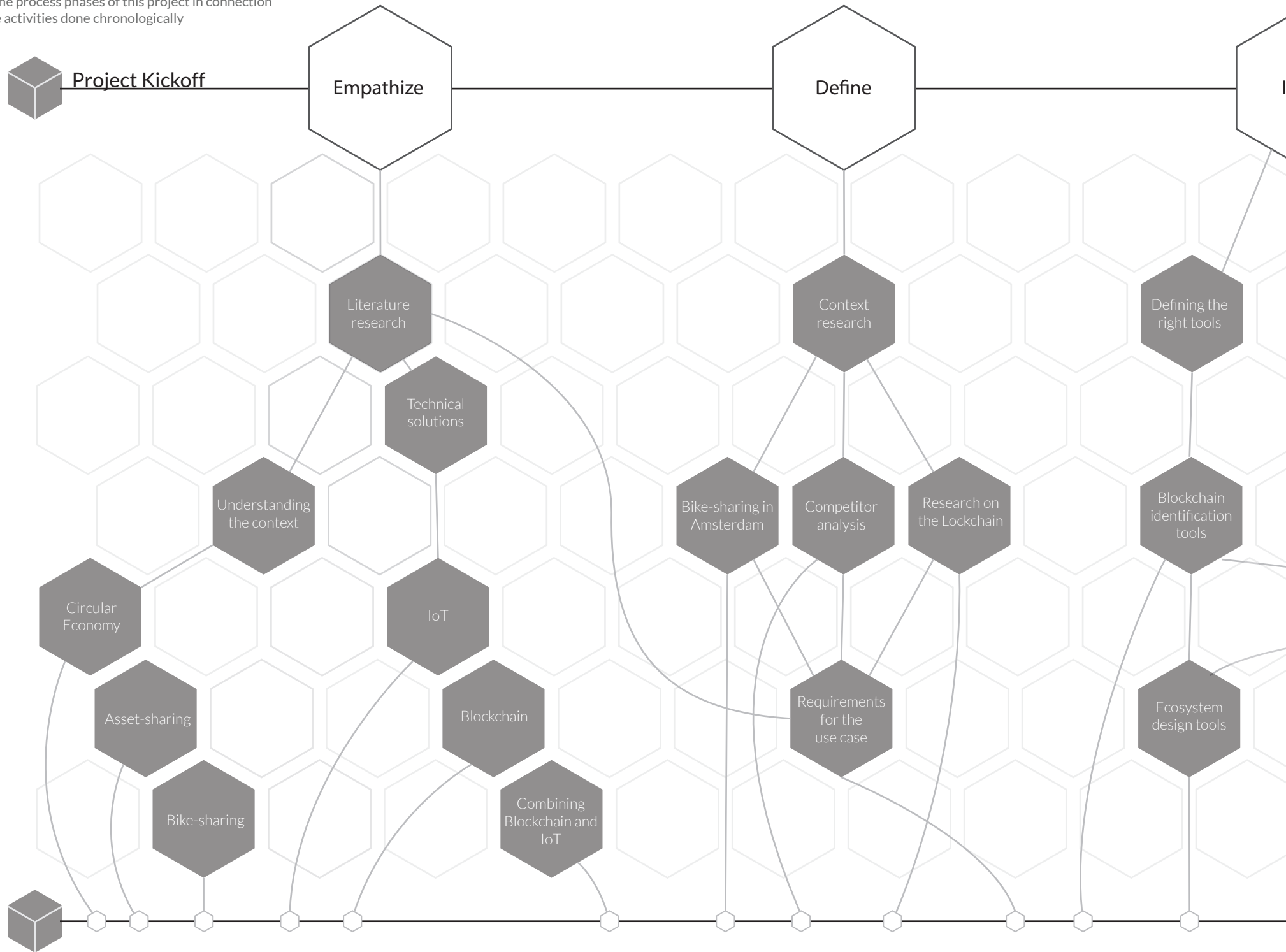
Evaluate

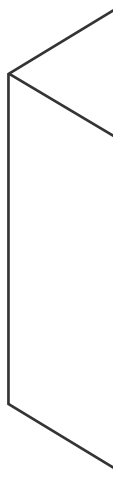
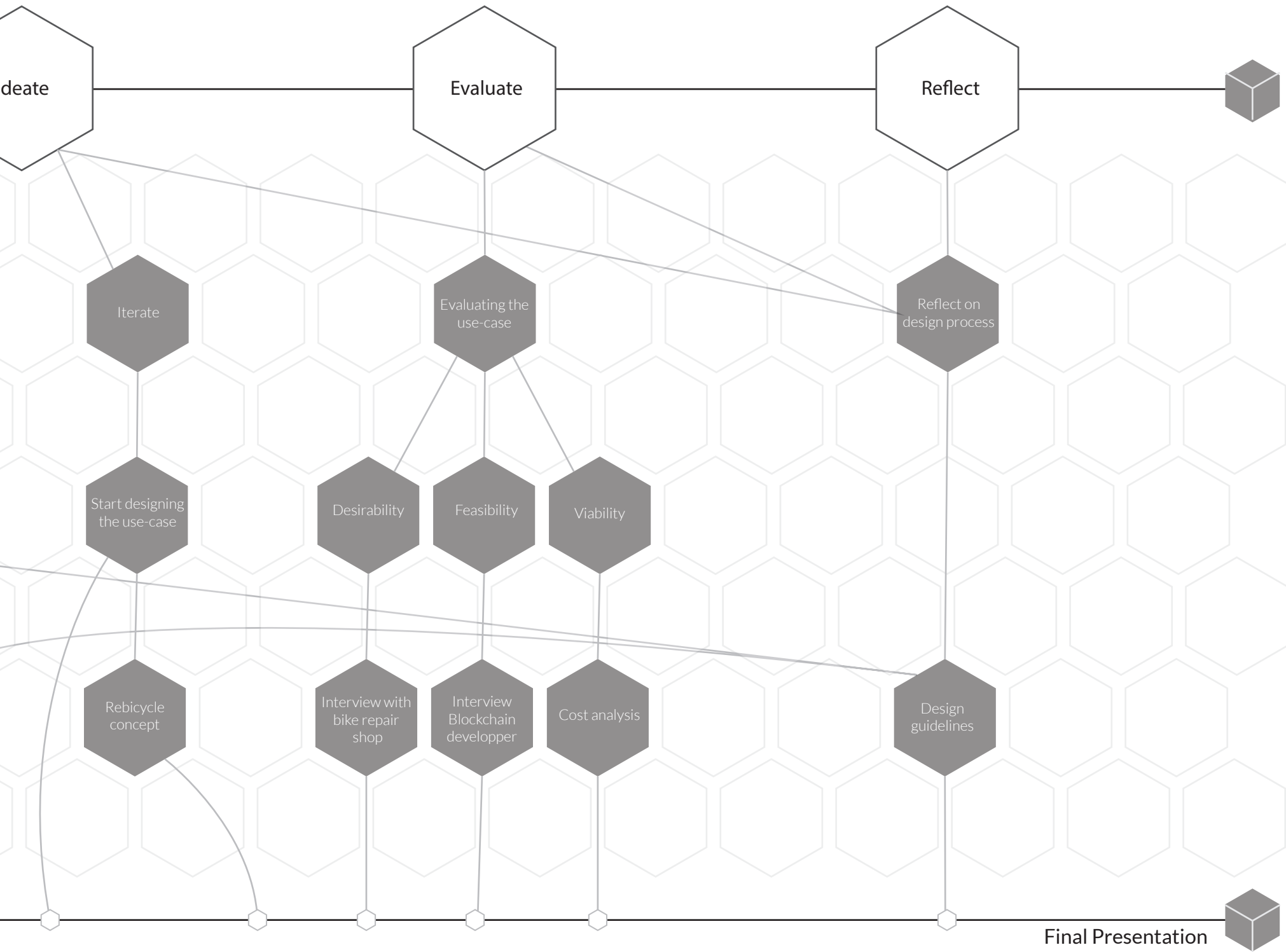
Once the concept is defined, the concept is evaluated with various actors such as Blockchain developers and a bike repair shop that played a role within this concept. These evaluations are done by interviews with the actors and helped to evaluate the economic viability, desirability for the actors in the system, and technical feasibility of the project.

Reflect

After finalizing the design of the concept for the use-case, a reflection was done on the process and tools used. Based on the process of designing a bike-sharing system with Blockchain and IoT, several challenges that were faced were mapped out and linked to the right tools to help to overcome these challenges. These tools were later included in guidelines for designing these systems. For the design of the guidelines, the tools used were modified to be more aimed at bike-sharing services.

Figure 9. The process phases of this project in connection with all the activities done chronologically





4.2 Define: Use-case research

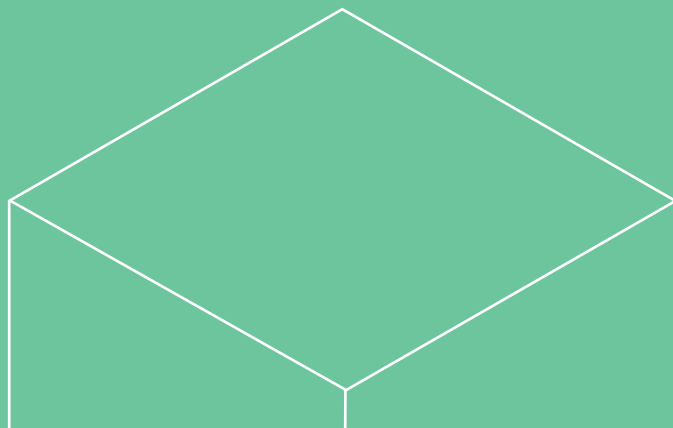
In order to get started with the use-case of the Lockchain. First a more detailed idea must be created on what problem the Lockchain actually wants to solve and why this is needed. The initial plan of the Lockchain, as was described by the developing parties, was to solve the bike problem in Amsterdam. First, the bike problem in Amsterdam was explored by analyzing information provided by the municipality. Secondly, to understand what a bike-sharing services requires to operate, market research was done on 5 bike-sharing services that are currently operating in the Netherlands. At last, to get a clear overview of the life cycle of a bicycle in Amsterdam and to understand how circular bike-sharing really is, an interview was done with the CEO of a bike refurbishing company called TradeFRM. The result of these use-case research is a list of requirements for the design of a new Blockchain based bike-sharing service.

4.2.1 Municipality information

According to the initial project brief of the Lockchain (Kryha, 2018), there is a large number of bikes currently present in Amsterdam, which are not being used on a daily basis. This means that these bikes are standing still most of the time which results in a “bike problem” for the municipality of Amsterdam. However, to create a better understanding of why this is actually a problem for the municipality and to see what the municipality is currently doing to counter this problem, more information on the current status of bikes present in the city is collected. This is done via desktop research on various reports regarding this problem that are publicly available via the online website of the municipality. In total 4 reports regarding, mobility, bike-sharing, the bike problem and bikes present in the city, are analyzed together with several news articles from local newspapers that are relevant for defining the context of the bike problem. The results of this research can be found in section 5.1.1

4.2.2 Market research

For creating a better understanding of what bike-sharing services entail and how they can operate, a market research is done. The information for this competitor analysis is found via various channels such as the websites/apps of the bike-sharing services, online videos and news articles. In this analysis the companies: Mobike, Swapfiets, OV-fiets, Urbee and Hello bike are being discussed. The bike-sharing services are being compared to each other to find the differences and similarities and to explore the different business models of each of these services. From these 5 companies, the essential aspects of bike-sharing services are determined which are part of the design requirements of the Lockchain use-case design.



4.2.3 Interview with TradeFRM

Since this project is a contribution to the Circular Economy, it is important to understand how bike-sharing services have impact on this and what the impact is of the current situation in Amsterdam. For this, it is important to know the entire life cycle of a bicycle in Amsterdam with an extra focus on the end. To get a better understanding of what happens to broken or abandoned bikes in Amsterdam, the CEO of a bicycle refurbishing company called TradeFRM is interviewed. TradeFRM has the monopoly to buy bikes from the Amsterdam city depot where abandoned bikes end up. Therefore, this interview helped with understanding what happens to these bikes and what is done with the refurbished bikes. This interview was done at the TradeFRM location in which also a tour was given throughout the company (Figure 10). For this interview, a list of questions was provided and several recordings were made. Although these questions were the guidance of the interview. Several follow-up questions were improvised during the interview. The learnings from this interview can be found in section (5.1.1.3)

4.2.4 The Lockchain

In order to be able to create a use-case in which the Lockchain is used, the lockchain project itself must be understood as well. For this, several meetings were held with the developers at Kryha to see what this lock is capable of and what not. These meetings existed mostly out of informal meetings at the office of Kryha and of regular meetings with the coach for this project from Kryha. From these meetings, the scope for the development of the Lockchain was used.

Figure 10. "TradeFRM Professional BV bikes" (TradeFRM, n.d.)



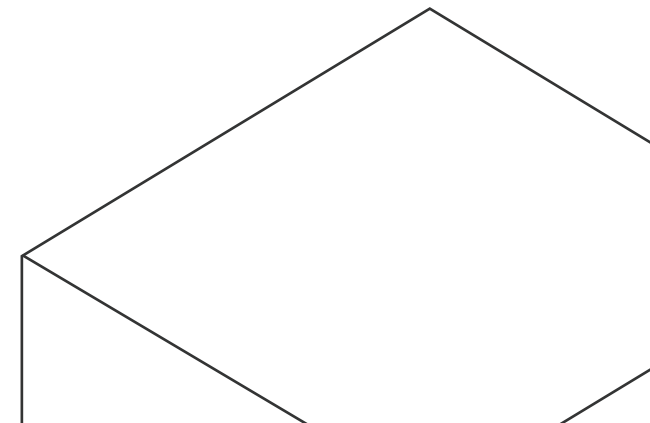
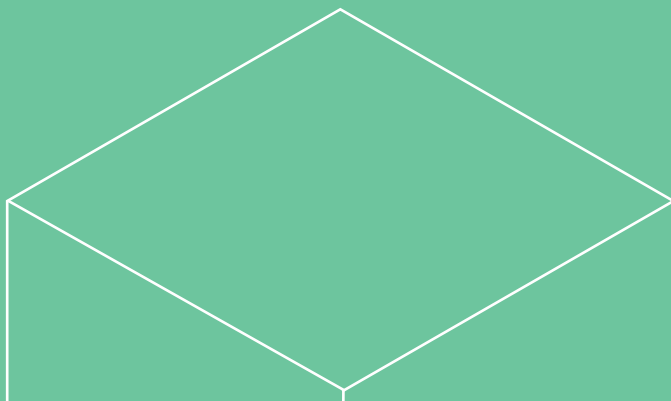
4.3 Ideation: Designing the use-case

With the knowledge gained in the Define phase using the methods described in 4.1, the ideation phase starts. During the Define phase, several ideas already started to develop. However, to create a concept out of these ideas, more ideation is required. For this ideation phase, several design tools are analyzed to see how they could be used for further developing the first ideas into a concept for the use-case.

4.3.1 Design tools analysis

To be able to design the use-case, several design tools are analyzed that could help with designing a Blockchain based bike-sharing services. The requirements for selecting these design tools come from the literature research and from the use-case research. From section 3.2.2.3 it can be seen that Blockchain is able to provide efficiency and trust. However, to see where this could be applied to in a bike-sharing system, more insights on where this could be implemented are required. Therefore section 5.3.2 will discuss different frameworks that could be used for identifying Blockchain opportunities.

Blockchain has been described by IBM (2016) as a team sport. If structured correctly, each additional network member should add additional value. Therefore, for designing Blockchain based businesses, it is important to understand the role of each member in the network and how it can provide value (IBM, 2016). For this, the ecosystem of the business should be understood. Therefore, multiple ecosystem design tools are researched. In this section, first the Blockchain identification tools will be discussed to set up the requirements for the ecosystem design tools analysis. Then, multiple ecosystem design tools will be discussed from which one will be chosen to be used in the design of the use-case.



4.3.2 Creating an Ecosystem

From the design tool research results (section 5.3.2), it was decided that the ecosystem design canvas from Lewrick et al (2018) would be a fitting tool to use for the design of a new bike-sharing concept. This tool contains 10 different steps to design a concept ecosystem. These steps are:

1. Create the core value proposition for the user/customer.
2. Determine and describe the actors in the business ecosystem
3. Arrange the actors in the different areas of the ecosystem map
4. Define the value streams and connect the actors with the value streams
5. Create awareness of the advantages and disadvantages of each actor
6. Multidimensional view of the business models of all actors and target business ecosystem
7. (Re)design of the ecosystem
8. Look at the decision makers and potential team members of the ecosystem
9. Form a team for the design of the new business ecosystem
10. Build the ecosystem steps by step

Since this use-case will not be implemented in reality during this project, only the first 7 steps will be used. For this project, these steps will be followed according to the canvas for an idea that was developed during the define phase.

4.3.3 Identify Blockchain opportunities

Once an ecosystem is designed, the Blockchain identification framework (Klein & Prinz, 2018) is used for identifying the possibility of Blockchain in the ecosystem. This means that the statements that are present on the Blockchain identification framework are put next to the ecosystem to check whether these statements were true for the different actors and value streams of the ecosystem. Once multiple boxes from the framework are checked, the Blockchain identification canvas is used for inspiration on how Blockchain could be implemented.

4.3.4 Design decisions

During the process of ideation, several design choices are to be made. To make these decisions, more information is required on the possibilities of these choices. To gather this information, either more information is collected via literature, desktop research or via coach meetings/expert meetings. In this way, it is made sure that all design choices are supported.

4.4 Evaluation

Once the concept is designed and supported with valid argumentation, the concept will be evaluated. This will be done on three aspects: Desirability, feasibility, and viability. These aspects are required to work in harmony for creating a good concept (IDEO, 2019) and will therefore be evaluated. For the desirability aspect, an interview is done with a mobile bike repair shop to see if a system like this is desired for their business model. For the technical feasibility, an interview is done with a developer from Blockchain studio Kryha to see if the proposed concept could be made and operated. For the viability of the concept, a cost analysis is made to project the costs and benefits for the system for the system to be operational.

4.4.1 Interview with bike repair shop

The interview with the mobile bike repair shop owner will exist out of a short meeting of half an hour in which the concept of the proposed concept is discussed. For this interview, first, a few questions are asked to be more aware of the bike repair shops interest and knowledge on bike-sharing services. Then, the concept is discussed in which especially the role of the bike repair shop is evaluated. This will be done with the help of the image of the ecosystem design and with the help of a screen image of the mobile application from the bike-sharing service. The first questions that are asked are:

- With which bike-sharing services are you familiar?
- In what way could bike-sharing services have an impact your business?
- How would you envision a role for your company in a bike-sharing service?
- What would be required for this to happen?
- Are you familiar with the technology: Blockchain?
- If yes, what do you know about it?
- If no, would you like to get a short explanation on this technology?

Second, the ecosystem visual of the use-case concept will be shown to the interviewee and the following questions will be discussed:

- Would your role in this system fit your current business model?
- What would be the prices you would handle for the proposed repairs?
- What is your opinion on the validation process on the performed repairs?
- Do you understand the role of Blockchain in this system?
- What would you change in this system?

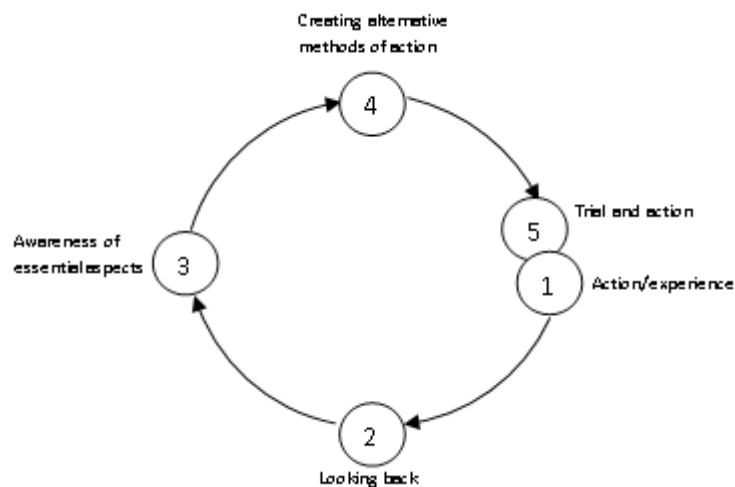
4.4.2 Interview with Blockchain developer

For the feasibility of the project, the concept of the use-case is discussed to see what would be technically speaking feasible and what not. For this meeting the ecosystem of the concept will be explained using a simplified image of the ecosystem. With this ecosystem explained, the discussion was started on if it is possible to create this system and what this would require. The results of this session are found in section 6.2.2.

4.4.3 Viability analysis

For checking the viability of the concept, a costs and revenues analysis was made. The input for this analysis came from desktop research, interviews and other bike-sharing services. However, not all numbers are based on findings. Multiple well-informed estimated guesses were made based on assumptions on how the Rebicycle concept could be implemented. The full argumentation of this analysis can be found in appendix C and the results in section 6.2.3

Figure 11. The Korthagen Reflection model (Korthagen & Vasalos, 2005)



4.5 Reflection: the design of the guidelines

For the design of the guidelines, a reflective analysis was done on the process of the use-case. For this reflection, the Reflection model of Korthagen is used as inspiration for the analysis (see figure 11). The main goal of this reflective process was to see what steps in the process were useful for the design of the use-case and what steps were less relevant. Also, more emphasis was laid on the use of the tools that were used for the design of the use-case.

By looking at the reflection on the process, new guidelines are designed for the design of Blockchain based bike-sharing services. For the design of these guidelines, the tools that were used in the process will be adjusted to be specifically aimed at bike-sharing services to make it easier for the user of the guidelines to use the guidelines for bike-sharing service cases. These adjustments are to be made using learnings from the research and by using the requirements of the use-case design.



5. Research Results



The research results chapter consists of two parts. 5.1 is focused on the results of the define phase in which the research for the use-case was done. This section will start with the research done on the municipality reports and the current bike situation in Amsterdam. Then, the results of the market research regarding several other bike-sharing services will be discussed. Also, the results of the Lockchain research are presented and at last, the requirements for the design of the use-case are discussed.

In the second part of this chapter (section 5.2), the results of the design tools analysis are discussed. These tools were used for the design of the use-case concept and the results of using these tools will also be discussed in this section.

5.1 Use-case research

5.1.1 The context

In the previous parts, knowledge was gathered that was needed to get a clear understanding of the main topics of the project. In this part of the report, the results of further in depth research is discussed for the design of the use-case for the Lockchain lock. Starting at discussing the current need for bike-sharing in Amsterdam from the perspective of the user and municipality, the scope for the use-case will be determined. By analyzing the current situation in Amsterdam and by looking at available bike-sharing initiatives present in Amsterdam, better design requirements for the Lockchain project can be created.

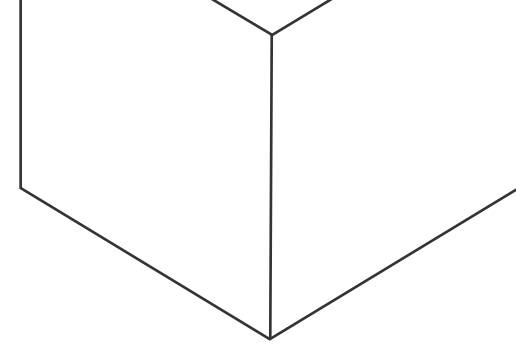
5.1.1.1 Why bike-sharing?

The Netherlands can be seen as a real bicycle country. Currently, there are approximately 25 million bikes in the Netherlands whereas there only live 17 million people. This means that on average Dutch people own 1.5 bikes per person which is the highest rate of bikes per person in the world (Verderfietsen.nl, 2019). Going by bike is, therefore, a popular way of transportation in the Netherlands. However, why would people still want to make use of a bike-sharing system if most people own a bike? There are a couple of reasons for this.

The first benefit can be found in the availability of the bike-sharing bikes. Bike-sharing systems are able to solve the last mile problem. The last mile problem refers to the short distance between home and public transit or the transit from stations to the workplace, which may be too far to walk (Shaheen et al, 2010). It is common in the Netherlands that people have to travel to work or school via public transportation. Even though it is allowed to take a bike on a train for a fee on special times, traveling with such a large object is not an ideal solution for daily travel. By providing-

bikes at stations and other public places, people are given a better mobility option which will encourage people to travel more via public transport. Therefore, Bike-sharing has the potential to play an important role in bridging the gap in existing transportation networks (Shaheen et al., 2010). Due to the quickly rising number of people choosing public transportation for various reasons (Algemeen Dagblad, 2019), the need for a bike-sharing solution has become more urgent. Furthermore, due to the wide availability of some bike-sharing services such as Mobike, bike-sharing platforms are also perfect for unplanned and spontaneous bike trips through the city. Whereas people who experience the last mile problem daily can benefit the most from bike-sharing services, tourists or visitors also benefit from the availability of the bikes.

A second incentive of using a bike-sharing system rather than an owned bike comes from a financial perspective. The purchase price of a bike is often quite high and the maintenance of the bike can be expensive as well. Moreover, by owning a bike, there is a risk that it gets stolen. This has been quite problematic for bike owners, especially for bike owners that live in the major cities of the Netherlands. Yearly approximately 80.000 bikes are stolen in Amsterdam alone (Fietsbond Amsterdam, n.d.). As mentioned in the IoT section (3.2.1) earlier, PSS like bike-sharing platforms can take away the burdens of ownership and provide the same outcome (i.e. transport via a bike). With these types of services, people are both paying for the use of the asset while also paying for not having these burdens. And since these services are often offered for a low price or a monthly subscription fee, using a bike-sharing system can be financially attractive (Shaheen et al., 2010).



5.1.1.2 The bike problem in Amsterdam

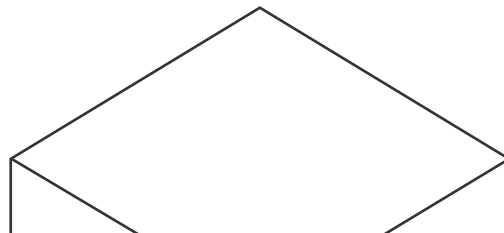
As is the case with the rest of the Netherlands, there are more bikes in Amsterdam than people who live there. Approximately 847.000 bikes are stored somewhere in the city. However, the people living in Amsterdam only make 665.000 bike trips each day. This means that more than 182.000 bikes are standing still for at least a whole day (Gemeente Amsterdam, 2017). Because of this, plenty of bike parking spots are occupied by these bikes causing a lack of parking spaces at bike hotspots. For instance, at certain hotspots, the amount of bikes parked there in relation to the amount of bike parking spaces is 195 percent. This means that the number of bikes parked at these locations is almost double the amount of what these parking spaces were designed for. This causes bikes to be parked in the middle of pass-throughs meaning they cause major obstructions for other users of the bike parking slots (Gemeente Amsterdam, 2017). Because of this over-crowdedness, public transport passengers have a hard time finding a parking space costing them more time which can be a hurdle for people in a hurry. Furthermore, the bikes can cause blockades which can create safety hazards when blockading emergency exit routes.

The large number of unused bikes does not only cause problems in bike parking places. Also in the city itself, bikes are often being misplaced causing obstructions on the sidewalks (figure 12) or car parking spots. According to the municipality, the costs of a misplaced bike could cost the municipality between 15-2500 euro each year. This number is based on the costs of the maintenance of the space the bikes take and the missing money that could be earned with those spaces. This number does not include the costs of the removal of the bike (Gemeente Amsterdam, 2019). For instance, if a bike is blocking a car parking space that would normally generate around 4 euro per hour for the municipality, the misplacement of the bikes causes the municipality to miss out on these earnings. According to the municipality, this is a common problem (Gemeente Amsterdam, 2019).

5.1.1.3 Bike-sharing in Amsterdam

In 2017 the bike-sharing companies Obike, Flickbike and Donkey Republic launched their free float bike-sharing services in the Capital of the Netherlands. This was the first time the concept of 4th generation free-floating bikes (See section 3.1.3.1), were introduced in a Dutch city. 7000 bikes were distributed all over Amsterdam for people to use (Libbenga, 2019). These bikes, however, caused major bike pollution in the city. These bikes were parked at spots where normally bikes of the inhabitants of Amsterdam where parked. The bike parking spots where already saturated and with the implementation of 7000 more bikes, the number of bikes that caused nuisance increased fast. Because of this, the municipality decided to ban all 4th generation bike-sharing services until strict regulations were put in place. This meant the end for Obike, Flickbike and donkey Republic in Amsterdam. At the start of 2019, the municipality decided to give bike-sharing a second chance by releasing a report with all new regulations for bike-sharing. In this report, they state that until 2022 they will run several bike-sharing experiments in different parts of Amsterdam (Gemeente Amsterdam, 2019). Some relevant regulations regarding docking-less bike-sharing as stated in this report are:

Figure 12. Bikes misplaced in Amsterdam



- In order to get permission for bike-sharing, bike-sharing companies must provide distribution options to make sure that the bikes are not standing still most of the time.
- The municipality strives to reach an average of out renting each bike 4 rides per day.
- Bike-sharing operators must share mobility data with the municipality to improve the mobility of the city
- Bike-sharing operators that collect personal data from the users must handle this data responsibly.
- Bikes can only be parked in predetermined parking areas.
- In order to receive permission to operate, the bike-sharing companies must pay the municipality.

5.1.1.4 Removing bikes from Amsterdam

As a result of the interview done with the CEO of tradeFRM, more information was collected on what happened to misplaced or abandoned bikes in Amsterdam. To reduce the losses made on misplaced bikes, remove blockages and maintain the flow through in bike parking lots, the municipality actively tries to reduce the number of misplaced bikes. Whenever a bike is wrongly parked or abandoned, the municipalities upholders will remove the bikes. The bikes that fall in this category are bikes that are not parked in a bicycle rack or bikes that have at least two faults that make them dysfunctional. (C. Kars, personal communication, April 23, 2019) Also, most bike racks have a limitation for the parking duration of the bikes. Whenever a bike exceeds that time it will be removed as well. The locks of these bikes will be cut open which enables them to bring the bikes to the regional bike depot. Each bike that has been removed by the municipality will cost around 70 euro in labor time and storage costs (Gemeente Amsterdam, 2019). At the regional bike depot, all bikes are being registered in the depot database. For this, they use the bike's unique frame number in combination with a picture of the bike. Via this database, people can check whether their bike is collected by the bike depot or not (C. Kars, personal communication, April 23, 2019).

The owner of the bike can come to the bike depot and collect his/her bike for a fee to partly cover the removal costs. Bikes that are not collected within 6 weeks are sold by the bike depot to a private company called TradeFRM.

TradeFRM is the only company that is allowed to buy the bikes from the depot of Amsterdam and several other cities. The price they have to pay for every bike is based on the state of the bike and is determined by a bike market expert at the bike depot. Once the company bought the bikes, they will be checked and registered in the bike trade register (DOR, Digitaal Opkoop Register) for bike dealers to prevent them from selling stolen bicycles. When everything checks out, all the bikes that are not perfectly functional will be stripped down from their parts which can be reused. All parts that are broken are being shredded to raw materials that can be recycled again. Parts that can be repaired are being refurbished and either sold or used on their bikes. The parts that are still usable will be sent to the bike repair departments of TradeFRM. Most of these repair departments consist of institutions that offer work to people with poor job prospects. From there, the bikes are made fully operational again and are ready to be sold and used again. The refurbished bikes are either being sold to bike merchants or donated to charity organizations (C. Kars, personal communication, April 23, 2019).

5.1.1.5 Bike-sharing irony

Although bike-sharing is a contribution to the Circular Economy due to the fewer resources needed, several Chinese bike-sharing companies are operating in a linear produce-use-dispose method. Due to their low production costs created by mass production of bicycles, it is more profitable for these companies to replace a bicycle with a minor defect by a new one rather than repairing the defect (C. Kars, personal communication, April 23, 2019). This causes them to throw away bikes as landfill which could be perfectly reused. Therefore, the end of the lifecycle of bike-sharing bikes should be taken into account as well in order to use bike-sharing as a contribution to the Circular Economy.

5.1.2 The market research

In order to design a bike-sharing system that operates with the Lockchain lock, a better understanding must be established on how bike-sharing services work. To understand how bike-sharing services operate and what challenges they face, different bike-sharing companies were analyzed. For this, Urbee, Mobike, OV-Fiets, Swapfiets and Hello bike were selected. These companies were chosen because they all operate in the Netherlands but have different characteristics and different ways of operating. These bike-sharing companies can act as a source of inspiration for the design of the use-case concept. In the next few parts, a short description of each of these companies is given. In appendix B an more elaborate comparison is provided which shows how these companies differ in their operations.

Swapfiets

Swapfiets was launched in 2015 but currently has more than 27.500 subscribers and is operational in nineteen cities in the Netherlands. With Swapfiets, you are able to rent your own Swapfiets for a monthly fee (15 euro or 12 euro for students). Every subscriber gets their own Swapfiets for as long as your Swapfiets is operational. Whenever the Swapfiets is broken, it will be rapidly replaced by the Swapfiets company. Swapfiets delivers the bikes to the desired location and picks them up once the subscription is canceled. Their key value proposition comes from offering an always working carefree bike so people do not have to deal with maintenance. In order to rent a Swapfiets, People have to create a Swapfiets account online which allows them to order a Swapfiets. There are different models of the Swapfiets available at different prices. For misuse of the bikes, fines must be paid. Also when the bike is stolen a fine of 40 euro (own risk fee) must be paid. This fine, however, will be higher if the bike was not locked properly. (Swapfiets, n.d.)

OV-Fiets

OV-Fiets is owned by the Dutch railway company NS. Currently, the OV-Fiets has more than 750.000 subscribers and has more than 4 million rides per year (AD, 2018). Currently the bikes are available at more than 300 locations near public transport stations (figure 13). The key value proposition of the NS for the OV-Fiets is to improve the door-to-door journey for travelers by offering the OV-fiets (NS, 2019) Due to their locations, they are a proper solution for the last mile problem. The business model of the OV-fiets is based on the pay-per-use principle, an OV-fiets costs 3,85 euro per 24 hours. This rate applies for 72 hours after this 5 euro is paid extra per 24 hours. The user has to return the OV-fiets to the same place where it is collected, otherwise, it costs 10 euro extra (Bootsma, 2019). In order to use an OV-fiets, a yearly subscription fee of 0.01 euro needs to be paid and the user must be in possession of a personal OV-Card. These cards cost 7,50 euro and requires personal data. (NS, n.d.)



Figure 13. The OV-fiets near a station in Amsterdam (NS, n.d.)

Mobike

Mobike is the largest free-float bike-sharing provider in the world. It was founded in China in 2015 and is now available in over 19 countries and 200 cities. It has over 200 million registered users and over 8,65 million daily users (Bootsma, 2019). Mobikes offers sturdy basic bicycles for a low price (figure 14). Mobike has been active in the Netherlands since 2017 and has been one of the first bike-sharing systems that made use of a smart lock that enabled free-floating. To use a Mobike, the user needs to create an account and upload a small amount of deposit in order to pay for the ride. Mobike offers a monthly subscription for 12 euro per month but is also usable as pay-per-ride for 1,50 euro per 20 minutes. Mobikes are docking-less and can be parked anywhere within a certain district. Via a technology called “Geofencing”, it is only allowed to park the bike within the district. If the bike is parked outside of this area, the last user will be fined 10 euro. Also, it is possible to receive lower prices if you occasionally report broken bikes or misplaced bikes. The discount will be rewarded for good behavior as a stimulation. Another form of good behavior is parking the bikes in the special Mobike bike racks which are located in various places in the city. (Mobike, n.d.)



Figure 14. A Mobike parked in the street (NS, n.d.)

Urbee

Urbee is a Dutch company that provides electric bikes for a wider public. Their goal is to reduce the number of car rides in the city by providing rides on electric vehicles that are perfect for trips of 0 - 20 kilometers. It is currently operating in 5 cities and has a total of 50 Urbee docking stations. Urbee offers a pay-per-ride service (3 euro for the first hours, 0,05 euro per minute and 15 euro for a day) and a Swapfiets like subscription model for 99 euro per month. When using a Urbee for one ride only, the Urbee must be brought back to the docking station where you rented it from. Here it must be properly locked via a Bluetooth lock or a fine will be given. (Urbee, n.d.)

Hello Bike

Hello Bike is an Amsterdam based startup that is currently operating at the Amsterdam-Zuidas. They started with providing a pay-per-use docked bike-sharing system in which with the help of a mobile app these bikes could be unlocked by the customer. However, due to the bike pollution of 2017, they decided to move to a different target group. Currently, Hello Bike only provides bikes for companies. Companies can buy a subscription for their employees who can then unlock a bike from the various Hello Bike docking stations that are spread across the city. Currently, Hello Bike is only operational in the business district of Amsterdam-Zuid. Hello Bike takes care of all maintenance of the bikes and docking stations. (T. de Graaf, personal communication, March 12, 2019)

5.1.3 The Lockchain

To define what could and could not be done with the Lockchain use-case more information was required on the initial Lockchain project of Kryha, TWTG and X.bike. For this, several meetings were held with employees of Kryha, and various project files were read. In this section, first a short summary on how the Lockchain operates from a technical perspective is explored. Secondly, several reasons to change directions from the initial Lockchain idea will be discussed.

5.1.3.1 The Lockchain tech

The Lockchain contains a hardware lock and a small circuit board that is linked to the locking system of the lock via a sensor. This circuit contains a bluetooth chip that enables the lock to communicate with a smartphone if this device is nearby. The Lockchain will be able to communicate if the lock is linked to the device, the identity of the device, and the state of the Lock to the smartphone. The smartphone contains a mobile application that is run via a cloud which contains the user data. Via this cloud service the node of the Blockchain is being accessed. Via this way of communication, a request from the smartphone to open the lock could be sent to the Lockchain (see figure 15). The Lockchain reads the request and formulates a challenge for the Blockchain. This challenge is encrypted and sent to the Blockchain node via the smartphone. The smartphone will add the users data from the cloud to the challenge so the Blockchain will know who is requesting to open/close the lock. The Blockchain decrypts this challenge and starts with checking the Blockchain for the transaction that is being requested. If the users wallet has enough cryptocurrency to make use of the lock, a transactions made to the owner of the Lockchains account. When this is complete a response message for the Lockchain is encrypted by the Blockchain technology and send via the smartphone back to the Lockchain. The Lockchain decrypts this message and verifies this response with the original challenge that was sent. Than the Lockchain is locked/unlocked.

5.1.3.2 Reasons for changing direction

While diving deeper into the initial plan of the Lockchain, several aspects of the project seemed to be undesirable based upon findings from the first two phases of this project, there were several reasons found that made pivoting from the original plan of the Lockchain project the better option.

The first reason for pivoting comes from the legislation of the municipality of Amsterdam. In the original Lockchain plan, users could buy a Lockchain and with that, enable their bike to be rented out to other peers via a mobile application. However, this renting would occur at public spaces where the bike is parked. In the regulations from the city of Amsterdam regarding bike-sharing is stated that people are not allowed to rent out their property for any monetary value in public spaces. In order to do so, all persons that would like to participate in the Lockchain network would have to request permission from the municipality (Gemeente Amsterdam, 2019). The municipality, however, requires to maintain an overview of the number of shared bikes in the city to prevent the city from being overcrowded and are therefore not likely to give permission for bike-sharing easily (Gemeente Amsterdam, 2019). This is one of the reasons to pivot from the idea of having a completely decentralized peer-to-peer bike-sharing system.

Another reason for pivoting from this initial plan comes from the fear of vandalism and theft. Vandalism and theft is the number one reason for bike-sharing services to fail in various cities (Chen, 2018). Companies such as Swappcar have included insurance policies in their services and several car insurances have special car sharing options. These insurances can decrease the fear of damages done to the owner's property. For a peer-to-peer bike-sharing service, these insurances do not exist. It is hard to determine the current value of bikes that are being handled in a peer-to-peer (H. van Vliet, personal communication, May 16, 2019). Also, with the Swappcar example, an extensive check of the car is done by the owner before and after renting out the car (Snappcar, n.d.). This would not be feasible for bike-sharing since the system should make travel throughout the city fast and efficient (Kryha, 2017).

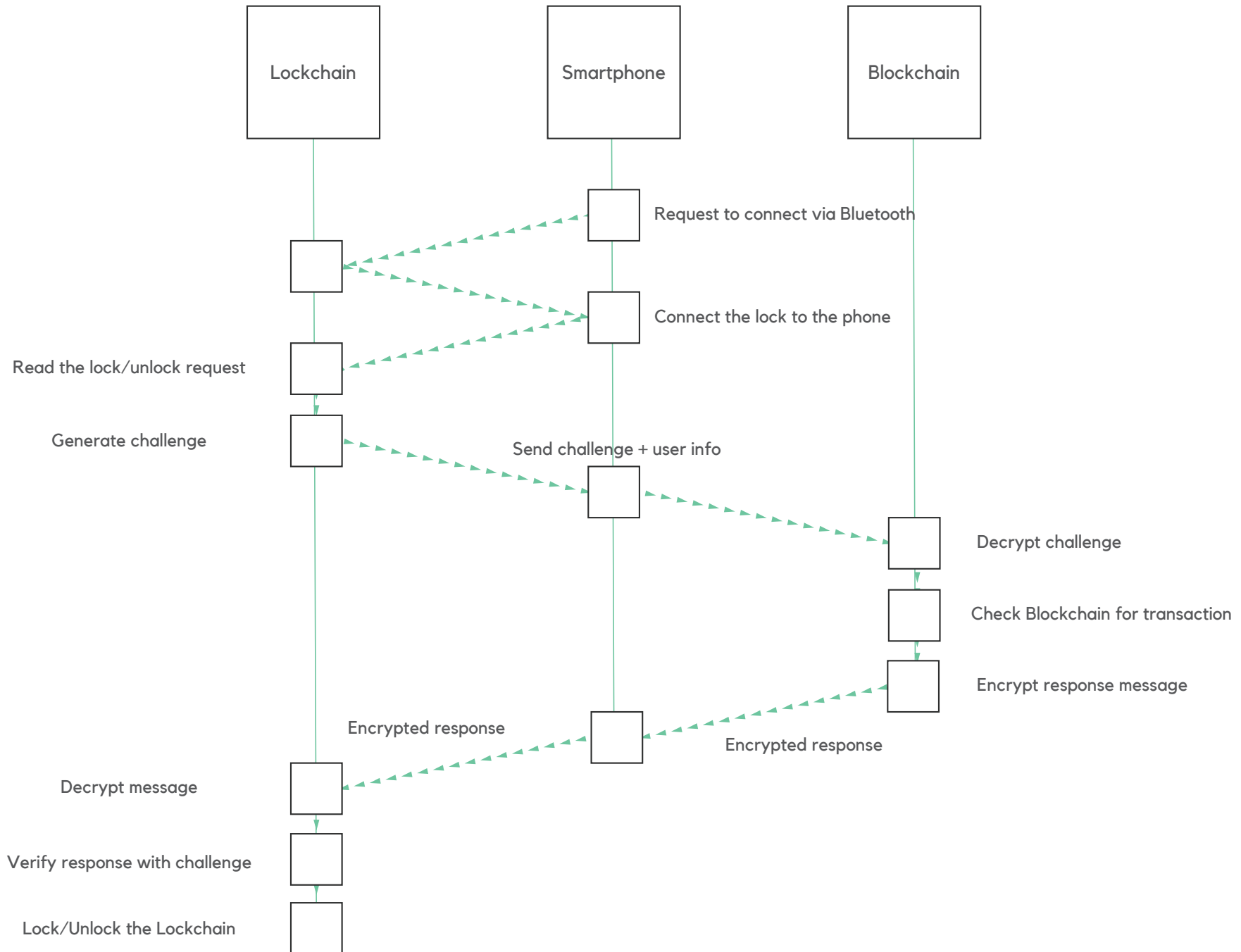


Figure 15. The system process of (un)locking the Lockchain

5.2 The use-case requirements

Because of the reasons for changing directions regarding the Lockchain project and the research done before, the decision was made to create a new bike-sharing service in which Blockchain and IoT could act as enabling technologies. For this design, several requirements were defined. These requirements were set from perspective of the end-user and of the municipality. The perspective of the user was taken to make the use-case desirable for the users and the perspective of the municipality was chosen to make sure that the use-case helps to solve the bike problem of the city. Furthermore, requirements were taken from the lessons learned in the literature research in chapter 3 and 5.1.

- The design should reduce the amount of wrongfully parked bikes and misplaced bikes.
- The design should reduce the number of unused bikes in the city.
- The design should take into account the redistribution of bike sharing bikes so bike hot-spots will not be overcrowded.
- The design should reduce the risks of misuse, vandalism and theft.

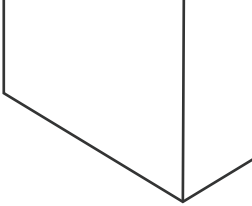
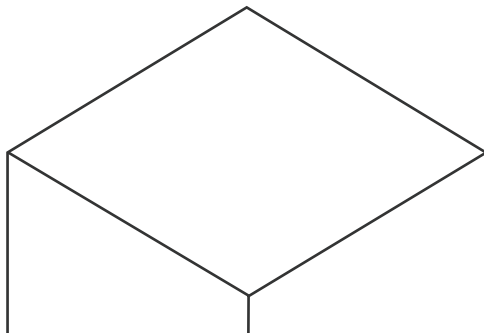
5.2.1 The municipality perspective

From the data on the municipality of Amsterdam on bicycles in the city, it can be seen that the majority of all bikes present in Amsterdam are in possession of the citizens of Amsterdam (Gemeente Amsterdam, 2017). Around 63 percent of these bikes are being used daily meaning a large portion of these bikes are not used daily. The key to lower the number of bikes in Amsterdam is to reduce the amount of bikes that is needed by the citizens living in Amsterdam. Bike-sharing has the potential to do so, however, from the previous bike-sharing initiatives that took place in Amsterdam it is clear that these bike-sharing systems can cause even more problems. Due to the addition of the bike-sharing system, the bike parking lots can get overcrowded causing obstructions. To counter these problems the following design requirements were formulated:

5.2.2 The user perspective

According to the bike-sharing research in Amsterdam done by Lam et al. (2018) the main reasons for using a bike-sharing system can be found in pricing, availability, and ease of use. This report even shows that 49,5 percent is willing to get use bike-sharing bikes if a system was in place that fulfills the requirements regarding these three aspects (Lam et al., 2018). Therefore, the following requirements were created:

- The design should make the bikes of the bike-sharing system widely available.
- The design should make the prices of the bikes financially attractive.
- The design should make the system easy to use for all involved users.



5.2.3 Requirements from research

In the literature research sections in chapter 3, multiple lessons were learned regarding CE, Blockchain IoT and bike-sharing. Based on the findings from those chapters, the following list of requirements was made.

From the CE section 3.1.1

- The design should make more efficient use of the available bikes by reducing the standstill time.
- The design should perform maintenance on the bikes to prolong the lifetime.
- The design should reuse and refurbish broken bikes and bike parts.

From the Bike-sharing section 3.1.3

- The design should take away the anonymity of the user.
- The design should use fines to make people more careful with their bikes.
- The design should use a digital information system for tracking the bikes.
- The design should create a proper redistribution system in order to guarantee the availability of the bike-sharing system.
- The design should adapt the bike-sharing system to the legislation of the city.

From the IoT section 3.2.1

- The design should find a way to create value with the data provided by the Lockchain.
- The design should decide upon how data would be collected and by what hardware.
- The design should create an Ecosystem regarding the IoT product to see what other parties can benefit from the data.

From the Blockchain section 3.2.2

- The design should use Blockchain to make the operations of the system more efficient in time and expenses.
- The design should use Blockchain for the security of the data use in the system and for personal data.
- The design should use Blockchain to decentralize the system.

From the Market Research section 5.1.2

From the competitor analysis it was seen that several aspects must be designed in order for the bike-sharing service to be operational like the other bike-sharing services. These are:

- Availability of the bikes
- Usability of the bikes
- Bike Characteristics
- Pricing strategy and Business model
- Responsibility and Fines
- Digital Platform
- Relocation and Redistribution
- Maintenance

5.3 The ideation design tools

5.3.1 Identifying Blockchain opportunities

In recent years it has become increasingly important for companies to know what Blockchain could do for them. Some literature already describe methods to define these opportunities. Klein et al, for instance propose the Blockchain identification framework (figure 16). With this Blockchain identification framework, existing use-cases from various businesses can be analyzed for Blockchain opportunities. They see that there are opportunities for Blockchain in the automation of the process, the handling of data and the role of the intermediary. This is in line with the core nature of Blockchain regarding efficiency and trust. This framework however, does only indicate if there is an opportunity for Blockchain but it does not show what this opportunity is and how this would affect the business. In other words, this framework does still need a design tool to figure out where these opportunities lay and how they can be developed.

For this Klein & Prinz (2018) created a use-case canvas on which 5 different elements regarding the use of Blockchain on the use-case, can be analyzed (figure 17). These elements include: Added value, Data and Process integrity, Decentral Network, Value and Rights and Automation. Underneath each of these aspects, the user of the canvas could indicate how these elements would be influenced by using Blockchain technology. However, this canvas does require the user to figure out how Blockchain could be implemented. It does give the user a good overview of the impact that Blockchain could have on the use-case of the user of the canvas.

Use Case Identification Framework for Blockchain

		Use Case
INTERMEDIARY	REPLACE ... to save time ... to reduce costs ... to simplify processes	<input type="checkbox"/> Replace
	ESTABLISH ... where trust between stakeholders is missing ... to provide a save and stable basis for transactions for flexible and temporary cooperation partners	<input type="checkbox"/> Establish
	MY BUSINESS MODEL ... can be replaced ... needs to be prepared for the new situation	<input type="checkbox"/> My Business Model
DATA	... have to be immutable ... have to be saved permanently and transparently	<input type="checkbox"/> Very important <input type="checkbox"/> Important <input type="checkbox"/> Rather unimportant <input type="checkbox"/> Unimportant
PROCESS	... can and should be performed autonomously while following given rules ... can be automated by using Smart Contracts	<input type="checkbox"/> 100% automatable <input type="checkbox"/> 67% automatable <input type="checkbox"/> 33% automatable <input type="checkbox"/> 0% automatable
Does the Use Case profit from Blockchain technology?		Very <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> Hardly

Figure 16. The Blockchain use-case identification framework (Klein & Prinz, 2018)

Another tool that could be used to identify Blockchain opportunities comes from Wust & Gervais (2019). They created a decision chart for using Blockchain aspect to identify if Blockchain should be used. They however go into more detail on which type of Blockchain should be used (permissioned/permission-less) as can be seen in figure 18. This method on the other hand does not take the efficiency aspects into account in terms of automation and cost/transaction time but can be perfectly used once a Blockchain opportunity was found to determine if a permission(less) Blockchain could be used.

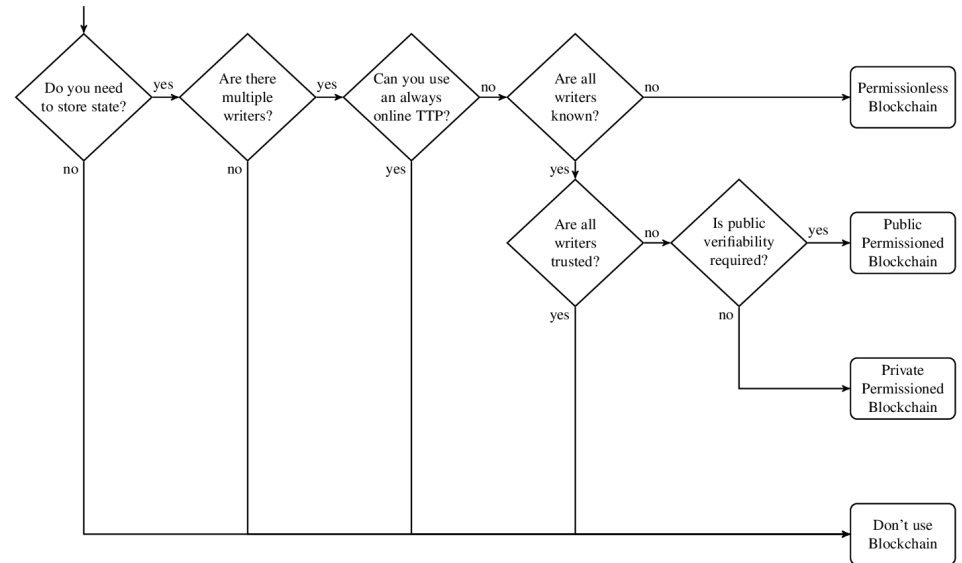


Figure 17. The Blockchain use-case identification canvas (Klein & Prinz, 2018)

Figure 18. "A chart for determining if Blockchain is appropriate" (Wust & Gervais, 2018)

Added value
Whose tasks are being supported? Which processes are being improved? Which unique characteristic is being achieved?

Data and Process Integrity
Which data have to be managed securely?


Decentral Network
Who is a partner in the network?

Values and Rights
Which value or which right is being transferred?

Automation
What can be automated?

Use case name:

Task Process Unique characteristic	R	Data	R	Partners	R	Values Rights	R	Automation	R
	<input type="checkbox"/> h <input type="checkbox"/> m <input type="checkbox"/> l		<input type="checkbox"/> h <input type="checkbox"/> m <input type="checkbox"/> l		<input type="checkbox"/> h <input type="checkbox"/> m <input type="checkbox"/> l		<input type="checkbox"/> h <input type="checkbox"/> m <input type="checkbox"/> l		<input type="checkbox"/> h <input type="checkbox"/> m <input type="checkbox"/> l
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Coming from a more practical background, the Blockchain consultancy company Kryha also has its own set of questions that can be asked for identifying Blockchain opportunities while exploring different concepts for their clients. These questions are formulated as:

- Are multiple parties involved, who do not or should not fully trust one another?
- Are multiple parties involved, who share the same data and need a common real-time view?
- Does the concept involve transactions of data or value?
- Does the concept require an immutable record/database?
- Is there a repeatable, predictable, ongoing process or transaction?
- Should new actions or data inputs be verified?

Based on if the answer is “yes” to these questions, Blockchain opportunities can be found within the new concept development. However, in order to see if Blockchain is also the best option for the client and what value it would bring, further concept design is needed. For this Kryha uses other methods such as Design thinking methods and the lean startup method.

In conclusion regarding the Blockchain identification tools, it can be said that in general all tools aim at the key principles of Blockchain to find possible implementation opportunities. Nevertheless, the key principles which are often formulated within the questions of the tools, do require more knowledge on what Blockchain is capable of to be useful. In most situations, answering the questions would only indicate that there is a possibility for Blockchain while not informing on what the possibility entails. However, the combination of the framework and canvas of Klein & Prinz (2018) offers inspiration for possibilities of implementing Blockchain. Therefore, these tools will be used for the design of the use-case regarding the Lockchain project.

5.3.2 Ecosystem design tools

5.3.2.1 Why an ecosystem design tool?

This ecosystem of a Blockchain system, includes all value providing actors and states in its essence the impact of the business. So if a business wants to know what the impact would be if they would start using Blockchain for a specific product/service, it is wise to analyze their current ecosystem to see which actors would be affected and redesign their ecosystem if necessary. Here ecosystem design can play a large role. However, ecosystem design is not only important in designing Blockchain services. Ecosystem design is widely used in other relevant sectors as well such as in designing for Circular Economy and IoT system design (Sinclair, 2017). (Ellen Macarthur Foundation, 2016). Also for asset-sharing services the ecosystem can play a large role. For asset-sharing services it is important to see which actors might have an impact on the asset and what the consequences of this impact are. Therefore, in this chapter multiple ecosystem design tools from various fields will be discussed and analyzed to see if they could be used as a tool for designing an ecosystem for the Lockchain use-case. The chosen tool will also be part of the guidelines for implementing Blockchain in asset-sharing services.

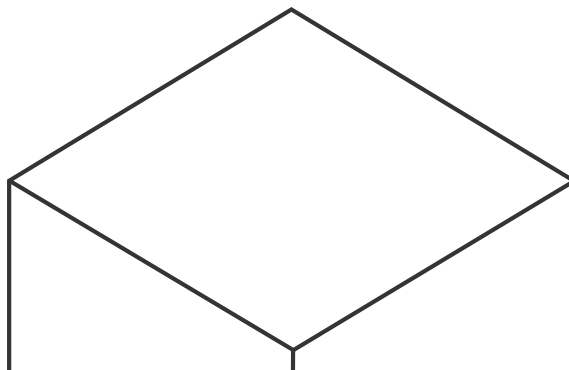
In order to see what the impact of applying Blockchain would be, it is important to know how to identify a Blockchain opportunity. In the previous chapter, a few Blockchain identification tools and frameworks were discussed. While looking at these different frameworks and the questions they ask, it becomes clear that the core of any identification framework is aimed at:

- Are all actors in the system are trustworthy?
- What processes could be automated?
- Is there a need for immutability, transparency and verification of data?
- What type of value transactions are being stored on the Blockchain?

5.3.2.2 Ecosystem tools for IoT

Ecosystems can play a large role in the design of IoT products. This is because IoT products are capable of creating value by collecting and transmitting data. This data can be valuable for other parties and used for other products. With this data, companies could enhance their operations or receive valuable feedback on the users of the product. However, to know which party could benefit from the data collected by the product, the other actors in the ecosystem should be known. Ecosystem design can play a large role in this field. With the ecosystem design of the IoT systems, the transaction of data can be influential to the entire business model of the system (Sinclair. 2017) Therefore, the transaction of data between the IoT device and other actors within the ecosystem should be very clear.

A first framework for IoT ecosystems could be found in literature from Leminen et al. (2012). They proposed a framework for IoT businesses in which they focused on positioning and analyzing the IoT business (figure 19). This would give a clear overview of the ecosystem of different IoT businesses which is a combination of different business ecosystems. They analyzed several different cases from the automotive industry and placed these in their framework. Although those analyses revealed some aspects of IoT businesses regarding M2M interactions, they did not go beyond the analysis of currently implemented businesses. Therefore, large gaps remain in their framework between the analysis of existing IoT businesses and the actual design and modeling of new IoT businesses. This is because their framework does not offer any iterative freedom or design possibilities but acts more as an analytic overview.



A more detailed design focused framework for business creation can be found in the Business Model Canvas (BMC) (Osterwalder et al., 2011). This framework was created as a design tool for new business models. It is also used to review and revise existing business models. It offers the freedom to iterate and gives a clear overview on various aspects of the business concept. Because of this overview, it is often used by innovation consultancies due to the ability to easily use this tool in a co-creation session. An important part of the BMC is the focus on the value proposition and how this value is being delivered to whom. Therefore, this framework is widely used for creating a clear overview of the processes of a business. Several ecosystem design tools use this framework in one way or another to help with defining the ecosystem of a business. One ecosystem design tool that utilizes the BMC as well is the IT Business Model Canvas by Ide et al. (2014). This variation on the original BMC is focused on creating an overview focused on IT businesses. It, however, does not differ much from the regular BMC. In a way the BMC is very suitable for the design of the Lockchain use-case, however, for it lacks a clear overview of the exact ecosystem of the business. Therefore, this tool will be used for other purposes.

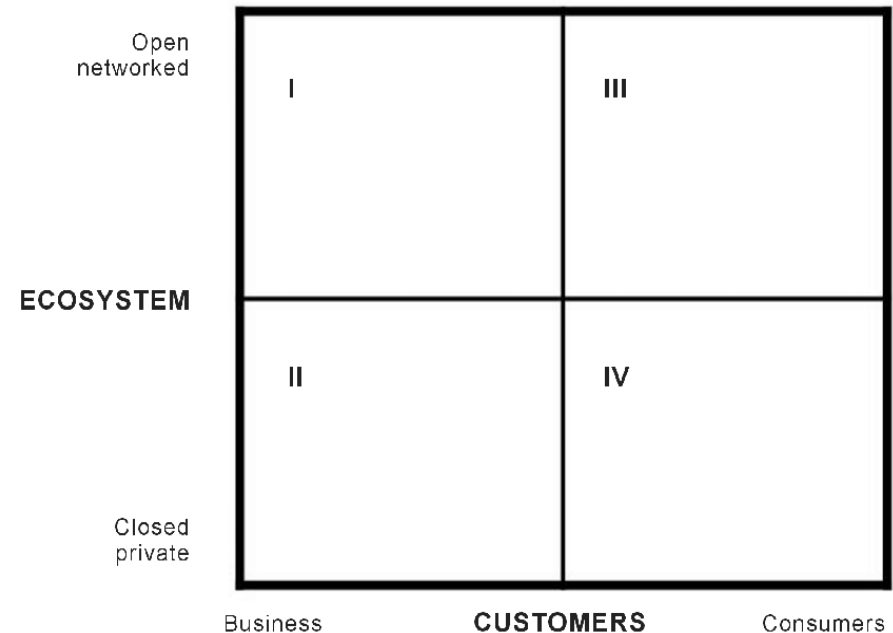
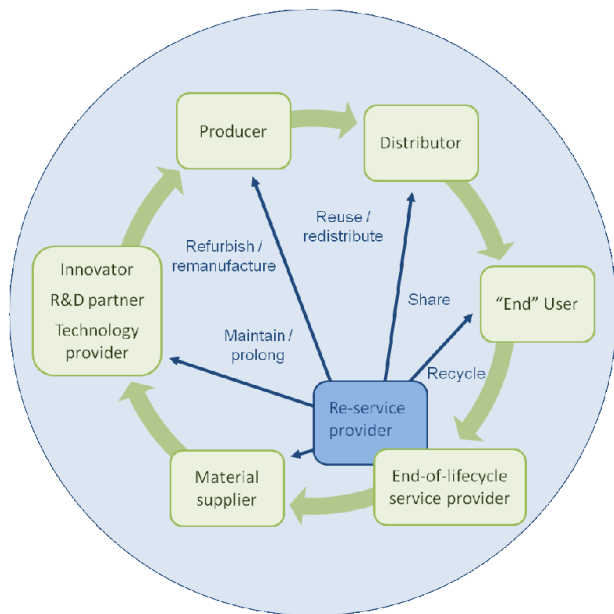


Figure 19. "Framework for analyzing diverse IoT business models" (Leminen et al., 2012)

A whole different ecosystem design tool can be found in the 6C framework of Rong et al. (2015). This tool can be used to analyze 6 dimensions from a business that together create a description of the ecosystem of the business. These 6 dimensions are: Context, Cooperation, Construct, Configuration, Capability and Change. By analyzing these dimensions for an IoT business, a systematic understanding of the IoT business ecosystem can be created (Rong et al. 2015). Although this tool lets the user of the framework to think about various aspects of the IoT business Ecosystem, this is done from an overall perspective which makes it hard to see the more detailed relations between actors. For asset-sharing services, the relation between the user and owners of the product is very important. Therefore this tool is not very suitable for this case.

In conclusion, the ecosystem design tools from the IoT field of work are more focused on the business ecosystem or the IT processes of the system. They however, lack the ability to analyze actors in the ecosystem which can be helpful for identifying Blockchain opportunities. Therefore, other tools were analyzed as well.

Figure 20. "Actors in the Circular Economy co-creation network" (Aminoff et al., 2016)



5.3.2.3 Ecosystem tools for CE

As mentioned before, the ecosystem of businesses plays a large role in the Circular Economy. This is because in the CE, to make businesses operate more circular, they must focus on the different actors present and the collaboration between actors. Most businesses do not have the departments to refurbish/repair/recycle their products meaning that they do have to collaborate with other parties to operate in a circular way. For these companies, it is more important to know what services other actors in an ecosystem can deliver. Since a company might work together with multiple other companies, CE ecosystem design tools often show a more visual way of designing ecosystems. This helps with creating an overview for all circular processes.

Aminoff et al. (2016) for instance created a tool for mapping multidimensional values for circular co-creation (figure 20). This tool is meant for companies to map out what value is created or destroyed by various actors in the ecosystem. The specific contribution of the framework is that it recognizes that the value created in different parts of networks is linked, and the change of value in one link influences the others (Aminoff et al., 2016). The framework consists of three steps. In the first step, the preliminary value proposition is mapped out. In the second step, all actors in the co-creation network are identified and mapped and in the third step, the value each actor creates/destroys is researched. This framework gives a good visual understanding of the actors in the ecosystem and the value each actor creates or destroys. It can be very useful for understanding the role of each actor and value streams in between different parties. For the CE it is useful since it shows if value is destroyed. If the destruction of value is identified, it is easier to redesign an ecosystem where this destruction is minimized. Overall, this would be a good tool to use for the Lockchain case if not another tool was found to be more useful.

The Business Ecosystem Design Canvas (BEDC)

From Lewrick et al. (2018) is a design tool focused on designing ecosystems. Although it is not specialized for IoT or CE, the canvas contains the most important elements of the loops for an iterative approach in the development of a business ecosystem. It has multiple steps that guide the user of the canvas from the value proposition to a test and prototype. For this it addresses the needs of users, the actors in the system, the value proposition, the definition of value streams and the results of prototype tests. Furthermore, it also takes a closer look at the advantages and disadvantages of each player and provides a multidimensional view of the business models (Lewrick et al., 2018). Because this framework also shows room for iterative design cycles it was found more suitable for the Lockchain use-case design. Furthermore it goes into more depth on the value streams that are offered by each actor in the ecosystem which makes it easier to apply the Blockchain identification tools from Klein & Prinz (2018). Therefore it was decided to use this tool for the design of the ecosystem in the Lockchain use-case.

Conclusion

So in conclusion, several frameworks and tools for identifying Blockchain and designing ecosystems were researched to find helpful tools for the design of the Lockchain use-case. Due to the overlapping questions of each of the Blockchain identification tools, requirements for a ecosystem design tool were chosen. This eventually resulted in choosing the BEDC tool from Lewrick et al. (2018) for the design of the ecosystem of the use-case. Once the actors and value streams of the ecosystem are identified, the Blockchain identification tools from Klein & Prinz (2018) could be used.

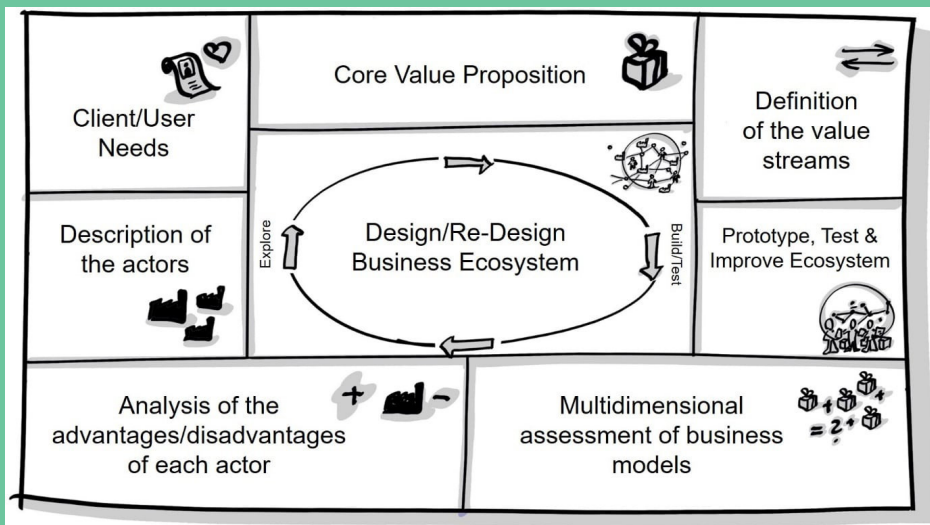


Figure 21. "Business Ecosystem Design Canvas (BEDC)" (Lewrick et al., 2018)

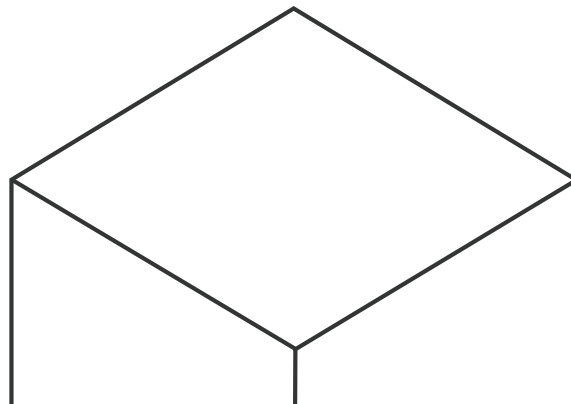
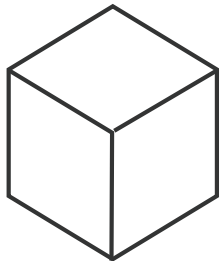


6. Use-case Result

Based on the design requirements from section 5.2 and with the help of the design tools from section 5.3, a concept was designed for a new bike-sharing system. The ideation for this concept was via multiple iterations that were made based on the requirements. These iterations were discussed with the company coach, mentor and chair of the university and other employees of Kryha which lead to a final concept: Rebicycle. Rebicycle is a truly circular bike-sharing system that worked with an IoT bicycle lock and Blockchain technology. The purpose of this concept is to solve the bike issues in Amsterdam by reducing the number of unused bikes and reduce the number of misplaced bikes. This chapter will explain this whole concept.

6.1 About the concept

In short, the Rebicycle concept is a bike-sharing system that operates as a decentralized autonomous organization on a Blockchain platform. The bikes that are used for this system come from refurbished abandoned bikes that were removed from the city. These bikes will be provided with a bicycle lock that is connected to the Decentralized Autonomous Organization (DAO) platform and mobile application. The system will be partly free to use by the citizens of Amsterdam for short trips and offered to commutes and tourists for prices similar to other bike-sharing services. The bikes will be distributed by TradeFRM which will also provide some maintenance to the bikes. Smaller reparations will be done by local (mobile) bike repair shops. Via the Blockchain platform all payments made to the system and by the system will be done securely and efficiently via cryptocurrencies. The DAO will operate the system completely autonomous and is governed via the holders of the cryptocurrency. Furthermore, the DAO gives people the opportunity to sell their bikes to the DAO so they become a part of the bike-sharing system. By doing so, people are able to earn money with their bikes in a way which is allowed by law. How this concept exactly operates will be explained in the next few parts.



6.1.1 The Rebicycle bikes

In most bike-sharing systems, a unified and easily recognizable bicycle is chosen. These bicycles are often part of the brand image of the bike-sharing company and are therefore not being refurbished or sold secondhand after the bikes are damaged (C. Kars, personal communication, April 23, 2019). This is not in line with the philosophy of the Circular Economy. Although the bike-sharing on itself contributes to a more efficient usage of the bike, bike-sharing is not a completely circular process. Therefore, it is important to also look at the whole life cycle of these bikes. In previous chapters, it was discussed that plenty of broken and abandoned bikes, end up at the city bike depot or at the company TradeFRM. These bikes were removed from the city which decreases the total number of bikes present in the city. Once TradeFRM refurbished these bikes, they are perfectly fine to be used again. For creating a more circular bike-sharing system, these bikes are to be used. By using abandoned bikes that were recently removed and redistribute them in the city for everyone to use. The amount of bikes present in the city does not increase in the same way as it did with the 2017 bike-sharing services (Section 5.1.1.2) (Gemeente Amsterdam, 2019).

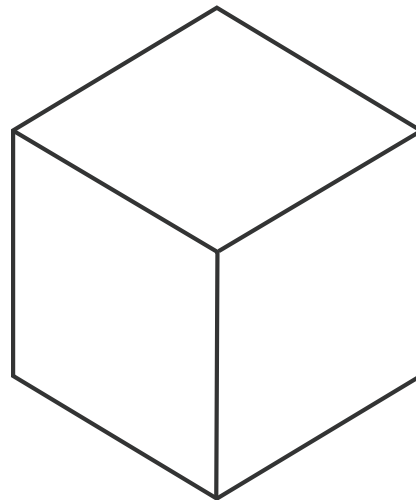
However, not all bikes that are refurbished by TradeFRM are usable for the Rebicycle bike-sharing system. From the other bike-sharing systems it can be seen that most bike-sharing companies use sturdy bicycles that require low maintenance. These bikes are often build with thick frames and strong parts. Therefore, it is wise to only use refurbished bikes that are a bit more sturdy and easy to repair. The suitability of the bike will be determined by the bike providing experts of TradeFRM. The average price that will be paid for the bikes by the DAO will be 50 euro per bike (C. Kars, personal communication, April 23, 2019) which is cheaper than the price of comparable bikes. This means that the bikes are not too expensive to replace and have a payback period. Once they find a refurbished bike suitable for the bike-sharing system, the bike is provided with a Lockchain lock and a bright green industrial sticker that is placed on the bike frame. This sticker will make the bicycle recognizable for the users of the Rebicycle system and makes it easier for the user to find the bike in crowded bike parking lots. The Lockchain locks will be provided by the Lockchain manufacturing party.

6.1.2 Distribution and relocation

Once the bikes are ready for use, TradeFRM will distribute the bikes to several bike-sharing hot-spots around the city. At these hot-spots, a special bike rack is placed for Rebicycles. These bike racks will be easily recognizable by their green color. Each of these Rebicycle hot-spots are monitored by tracking the amount of parked bikes to see the amount of Rebicycles present at the hot-spots. This is done similar to Mobikes via the GPS data of the users smartphone. If this number is exceeding 100% of it's capacity, Rebicycle users looking for a bike nearby (within 250 meters) will be asked to pick up a Rebicycle from this hot-spot even though another bike might be closer. If this number rises to 150%, a redistribution vehicle, provided by TradeFRM will be asked by the DAO to pick up the excessive amount of bikes and redistribute them over the other bike hot-spots. This will retain the availability of the bikes at the bike hot-spots while also removing potential obstructions. For every request done by the DAO to TradeFRM, TradeFRM will receive a certain amount of Rebicycle cryptocurrencies which they can exchange for euro. The amount of money that is given to TradeFRM for the replacement of the bikes is all stated in the smart contracts and will be discussed in a later chapter as well. In the future other parties that are experienced in relocating bikes could be operational in this system as well and compete with tradeFRM.

6.1.3 Maintenance and repairs

If a user of the Rebicycle system notices that the bike is broken or missing a part, it can send a notification of this damage in the mobile Rebicycle application in which the user indicates what is broken. Once the user has done this, several situations can happen. First of al, the user could bring the broken bike to a bike repair shop nearby. The location of these local bike repair shops are indicated in the mobile application. For doing so the user will be rewarded with Rebicycle coins that can be spend within the system. In a second option, the user only notifies the system via the application but decides to take another bike instead. The bike will be labeled as broken in the application. Mobile bike repair shops which have the app, will be notified about the broken bikes location (figure 22). They will go to the location and try to repair the bike. Once they are done with this, a payment in the form of Rebicycle-coins will be made from the DAO to the mobile bike repairs shops wallet. The execution of this payment is also stated in one of the smart contracts of the DAO. A third option is the repair of the bikes done by TradeFRM. While redistributing bikes to different hot-spots, broken bikes at these hot-spots will be brought back to the TradeFRM workplace where the bikes will be repaired. Once they are repaired, they will be brought back to one of the bike-sharing hot-spots where they can be used again.



The bike repair shops will only be able to repair certain broken parts. This is because TradeFRM has an enormous supply for various parts which are cheaper to use and more circular than to replace the broken parts with new parts. Also, some bike repair shops are fraudulent and will try to replace still working parts by new parts. A smart contract, however, will make this unable for them. This smart contract will be explained later. The problems that will be solved by the bike repair shops are:

- Flat tires
- Stolen or broken lights
- Loose or broken chains

All other parts that need to be replaced, will be done by TradeFRM. They have machinery that is uniquely designed for refurbishing old parts into new ones such as a wheel repair machine. If a bike is brought to a bike repair shop while it should be repaired by TradeFRM, the bike will be collected by TradeFRM.

Like all bikes, there will be a certain time that the bike is broken beyond repair. If this is the case with a Rebicycle, the bike will be brought to TradeFRM which will strip the bike for usable parts. These parts will be reused in other bikes. All parts that are not repairable anymore will be shredded to ground materials and will be recycled. Currently all bikes refurbished by TradeFRM contain 80 % reused bike parts (C. Kars, personal communication, April 23, 2019). This means that their bikes are very much aligned with the philosophy of the Circular Economy.



Figure 22. A mobile bike repair shop

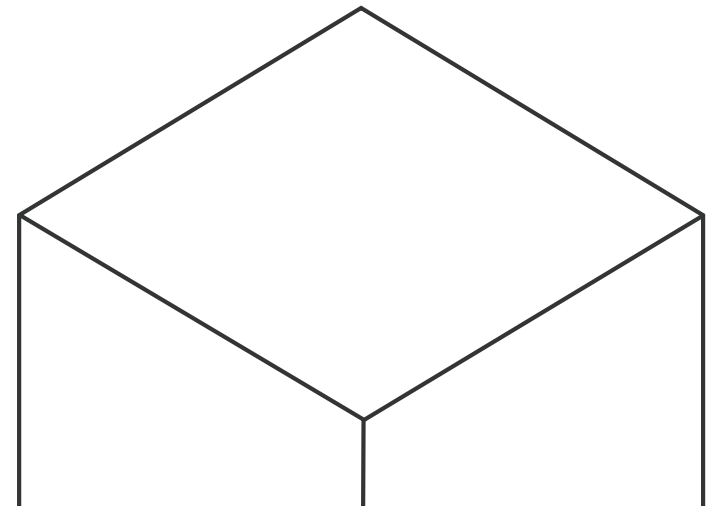
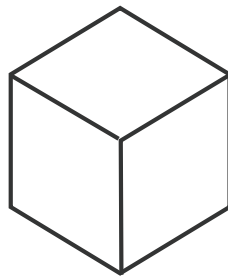
6.1.4 Users and interaction

The target group of this concept consists mainly of citizens of Amsterdam which frequently travel by bicycle through the city. They currently use their own bikes most of the time for small trips and store their bikes either in their garden or in front of their houses. This target group was chosen since these people tend to make trips through Amsterdam that are not only work/public transport related (Gemeente Amsterdam, 2017). This causes a better distribution of bikes widespread over the city to ensure the availability of the bikes. Nevertheless, tourists and commuters will also be able to use the Rebicycles.

Everyone who wants to use a Rebicycle is required to download a mobile application for free from an app store. To use the mobile application, the user must enter its personal data and home address, this data will be encrypted and stored on an additional server which ensures the security of the data. There will be a longer explanation about this in the data management section (6.1.7). Once a user created an account, the app will show a map with all bikes available in the area. The user is able to select the bike he/she wants to use and is able to make a reservation for this bike for 20 minutes. If a bike is reserved, it is no longer displayed on the map. Also, by selecting the bike, the user will see a picture of the bike and what functionalities it has such as gears, brakes and lighting.

Once the user arrives at the location of the bike, he/she will be able to unlock the bike via the low energy bluetooth connection with the Lockchain. To activate the lock, the user needs to be close by and scan a QR code that is printed on the Lock. Once this is done, the application will verify the QR code and open the bike lock via the bluetooth connection. The moment the lock is opened, a timer will start on the mobile application. This timer will track the time the bike is used by the user which will determine the price of the ride. Also, the phone of the user will use the GPS of the phone to track the ride which can only be seen by the user of the bike. When the user is done with the bike, he/she can close the lock of the bike which will automatically end the trip of the bike. Nevertheless, the user is not allowed to park the bike wherever they want.

Parking the Rebicycles will only be possible in certain areas across the city. Regulations of the municipality causes some areas to be unavailable for bike-sharing. Within the mobile application, these areas are marked on the map via "Geofencing". If the user of the bike would be in one of those areas, the user would not be able to lock the bike. Also, the users of the Rebicycle bikes will be urged to place the bikes properly in bike racks or bike parking lots. If a bike is found to be obstructive, the last user of the bike will be held responsible and will receive a fine to its account.



6.1.5 Pricing strategy and revenue

To make the system more attractive for the citizens of Amsterdam, the pricing strategy for the use of the bikes should be aligned with the requirements for the pricing strategy based on the findings presented in the requirements chapter. Since it was found that people were willing to sell their bikes if the pricing, availability and ease of use are satisfactory and the largest number of bikes belong to the citizens of Amsterdam, a special price deal is given to these citizens. Every citizen that wants to use the Rebicycles can do so, for free, for the first 15 minutes of using the bike, twice a day (15 minute intermission period) and receives a 50% discount on the other prices. The average speed of a cyclist in Amsterdam is 15 km/h (Gemeente Amsterdam, 2017) meaning that in 12 minutes a cyclist could ride 3 kilometers in ideal circumstances in theory. Nevertheless, in reality this distance will be a bit shorter due to traffic and traffic lights. A large part of all trips done in Amsterdam are for visiting some friends or going to the grocery store. According to the CBS (2010), these trips are on average only 1.5 kilometers long meaning that these trips are well fitted for the 15 minute of free cycling.

By providing the bikes for free for two rides a day the citizens are given an extra incentive to sell their own bikes. Having a bike will cost eventually more in care and maintenance than using this system for short daily trips. For trips longer than 15 minutes, a small fee of 0,75 euro cents in Rebicycle-coins will be asked per 15 minutes extra (figure 23). It is however, also possible for the citizens to buy a full subscription on the system for 6 euro per month which gives the users unlimited access to the bike rides. Another option is to rent a bike for a full 24 hours. For this the citizen has to pay 2 euro worth of Rebicycle-coins. For non-Amsterdam citizens, a different pricing strategy is used. These prices are comparable to the pricing strategy used by Mobike for the monthly subscription fees and price per rides and OV-fiets for daily rent.

What	General user	Amsterdam Citizen
First 15 minute ride	1,50 euro	free
Extra 15 minutes	1,50 euro	0,75 euro
Monthly subscription	12 euro	6 euro
24 hour rent	4 euro	2 euro

Figure 23. Prices of the Rebicycle usage

The initial investment for this system will come from an Initial Coin Offering (ICO) that is provided by the DAO itself. Via the ICO, investors and new users will be able to buy Rebicycle-coins which can be used in the system. The money that is generated via this ICO will be spend on the first batch of bikes and locks. However, also money will be needed for the creation of the DAO, the mobile app and maintenance of the app and (cloud) servers. By having Rebicycle-coins, the holder of the coins has a stake in the DAO governance and is able to propose changes in the system (H. Dabian, personal communication, August 29, 2019). In order for these changes to be made, a large part of all the coin holders need to accept these changes. The percentage of holders needed for the changes is decided upon before the launch of the ICO (Gray, 2019). Because of the voting power that is linked to the Rebicycle-coins, buying these coins can be an attractive option for various actors that want to have a stake in the system such as the municipality and the Blockchain developers. Also, since the system would reduce other costs for the municipality, this investment would be a good investment for them. Other incomes for this system come from fines that are given for misusing the system or from Rebicycle-coins sold. The fines will be elaborated more on in the responsibility and fines section (6.1.8).

6.1.6 Digital interface

There are different actors in the system that require a different form of digital interface from the system. For instance, for the user it is more important to see where an usable bike (figure 25) is, whereas it for TradeFRM or bike repair shops more important is to see where broken bikes are located. Therefore, the mobile application will have different interfaces for different types of users. There are different functions available for each actor.

For the users of the bikes the following functions are available (figure 24):

- Information about the users account and wallet history
- Finding a bike via a map of the city
- Reserving a bike
- Reporting broken bikes
- Reporting misplaced or stolen bikes
- Buying Rebicycle tokens
- An option to open the bike lock

For the Bike repair shops these functions are made:

- Information display for the bike repair shops account and wallet history
- Finding a broken bike via a map
- Getting information on what is broken
- A button for inserting proof of repairing the bike as requested
- Collecting Rebicycle coins from the repair
- An option to open the bike lock

For the distributor and law enforcement the application will include:

- A map that indicates the number of bikes per hot-spot
- A map that indicates misplaced bikes
- A map that shows the broken bikes
- Report stolen bikes
- Report misplaced bikes
- An option to open the lock

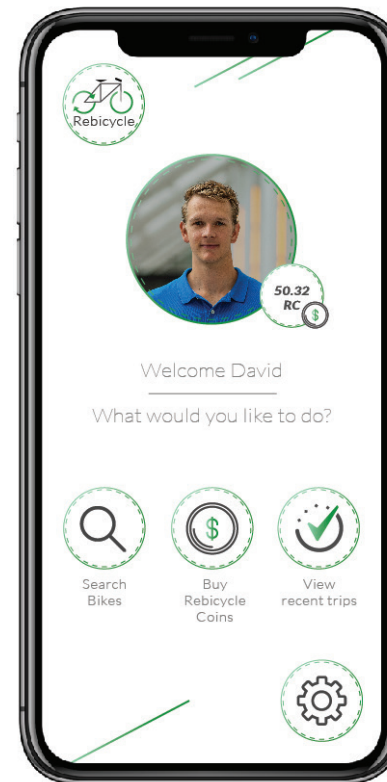


Figure 24. The Rebicycle app home screen for regular users



Figure 25. Various screens of the Rebicycle app

6.1.7 Data management

As mentioned in the user interaction part, in order to use the Rebicycles, the user is required to fill in their personal details. These details include: Name, address, age, e-mail and phone number. This data will be encrypted and stored on an external cloud server which is hosted by and secured by a third party that is being paid with the revenue made by the DAO. The deal that is made with the third party cloud server will be done via the creating party of the DAO and the first investment in the cloud will be done via the collected funds from an ICO. The data in this cloud will only be visible with the private key that can be stored on the Blockchain to secure the data.

A key aspect of the Blockchain technology as mentioned before, is the transparency of the transactions. In a regular Blockchain, all nodes have access to every transaction done on the Blockchain. Since this is not ideal for privacy sensitive data, Blockchain can not always be used. The Oasis Blockchain however, found a way to conceal transactions and make them only accessible for parties that have a key for this data (Oasis Team, 2019). Therefore, the privacy sensitive data transactions that could be stored on the Blockchain, will only be accessible by the user with their private key. This gives the user the ability to share their data with other parties by providing these parties with the key to this data. This could be used for the encrypted users personal data that is stored on the cloud. By placing the description key to the personal data on the Oasis Blockchain. Only the holder of the private key to the decryption key can decrypt the user data in the cloud (figure 26).

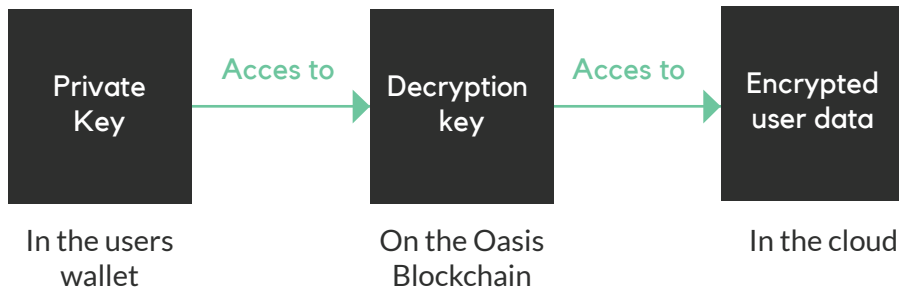
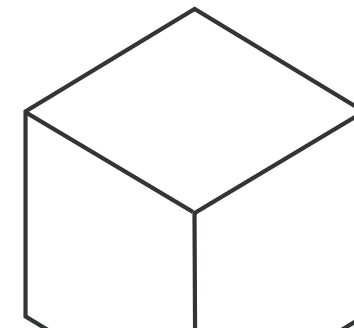


Figure 26. Data management

Even though the users data could potentially be stored encrypted on the Oasis Blockchain without the help of the cloud. This is not allowed for this use-case. This has to do with the General Data Protection Regulation (GDPR). These European regulations state that all data from a person should be erasable from the internet. However, due to Blockchain immutability, this would not be possible. By using a cloud server, it is possible to erase the encrypted user data which would make the decryption key that is stored on Oasis useless.

Other data that is privacy sensitive and will be stored in the same way, is GPS data that is collected during the trip with the bike. These bike trips will be only visible to the user of the bike. However, the user of the bike will be able to sell the decryption key to this data to other parties for Rebicycle-coins. This data is very useful for the mobility of cities or could be used for marketing purposes. Therefore, third parties could be interested in buying this data. The user will therefore be asked to sell their data. For every trip they share, the user will receive a small amount of Rebicycle-coins in return.

At last, there is also data that does not require disclosure. The last location of the bike for instance, should be visible to everyone of the network so the bike can be found easily. This data will be stored on the Blockchain in the form of coordinates and the key for this data will be publicly available for every user in the network. With the location of the bike, also the current status of the bike will be stated. This status will inform bike repair shops or redistributing parties to collect the bike if its state reports a need for maintenance.



6.1.8 Fines and vandalism

From the previous generations of bike-sharing, it can be seen that the vandalism and theft were the main reason for failing bike-sharing services (see section 3.1.3.2). It was found that by taking away the anonymity of the users for the system and make them responsible for the bikes (Shaheen et al. 2010). As mentioned before, the users of the system will have to put in their personal details and with that, they can be held responsible for theft and vandalism. They will receive a fine for misusing or misplacing a bike. If a bike was found to be parked somewhere illegally, the finder of the bike will be able to report the misplaced bike in the application. Also, if the bike is not present on the spot or damaged, a notification should be given in the application. By doing so a smart contract of the DAO will be activated and a fine will be sent to the end user.

The fines will be sent to the home address of the user with a request to pay the fine via the application. The last user of the bike could however, protect his/herself from this fine by taking a picture of how and where the user stalled the bike. A question for taking a picture will be asked after every trip when the lock is closed. By doing so the bike might be easier to find for the next user as well. This option however will only be available for 30 seconds after closing the lock so the pictures can not be uploaded later.

If the user did not take a picture and a notification about an infringement of the bike was done by another user the fines in figure 27 will be given. These fines are based on prices handled by existing bike-sharing services.

Figure 27. Penalties for infringements

Infringement	Penalty
Inappropriate parking	10 euro
Bike parts broken	5 to 10 euro based on damage
Bike not at the parked spot	25 euro
Bike not properly locked	5 euro

If a bike is parked inappropriately and causes obstructions on the road or pavement, it is likely that a city law enforcer will notice the bike. Normally, if a bike is misplaced in the city, a law enforcer will notify the city depot who will come to collect the bike. If the bike is locked, the lock will be cut open than the bike will be transported to the city depot (C. Kars, personal communication, April 23, 2019). However, if the law enforcers of the city will come across a Rebicycle that is misplaced, the law enforcer could open the Rebicycle application and open the bike. All law enforcement employees on duty will have a special account which has access to all the Rebicycles involved. This makes it easier for them to move the bikes to a nearby hot-spot or bike rack. By doing so, they save the municipality 70 euro in removal and transportation costs. These costs would normally be made via ordering the bike depot to remove the bike. Also misplaced bikes could cost the municipality between 15 and 2500 euro per year as was stated in the empathize part. This is a financial benefit for the municipality which acts as an incentive for investing in this system.

If a law enforcer comes across a stolen Rebicycle without a Lockchain lock or a sticker, the bike will be taken to the bike depot just as other stolen bikes. At the bike depot, the frame number of the bike will be checked in the national bike theft register which will indicate that this bike is indeed stolen. Every bike that will be missing from the system will be checked into the national bike theft register by the DAO as is programmed in the system. This means that whenever a bike is removed by the city, or found without a lock by the police, the bike depot will be aware that the bike is part of the bike-sharing network. The bike will be picked up by TradeFRM and a new Lockchain will be installed.

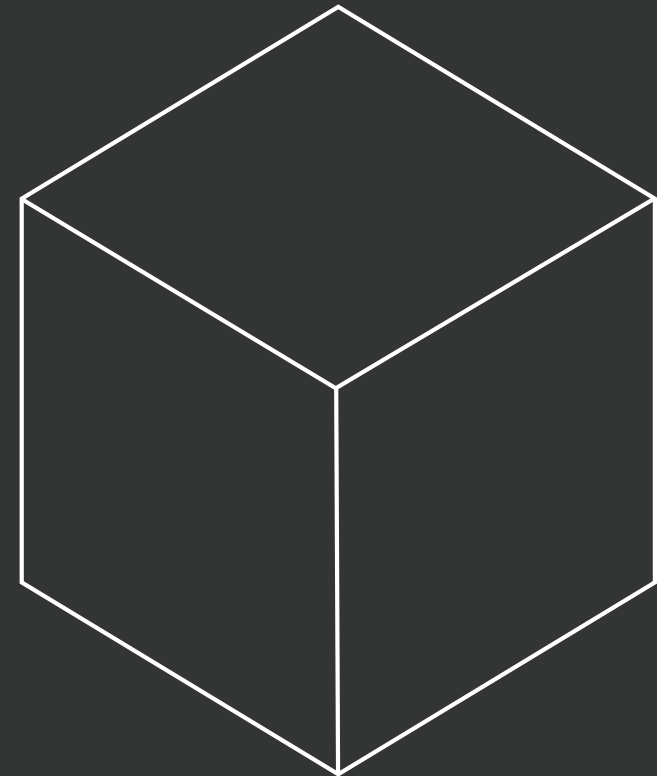
6.1.9 Expanding the bike fleet

If the incentives (availability, price, ease of use) for using the bike-sharing platform work for the users. Chances are that they do not require a personal bicycle anymore. They however, could use their personal bike to generate money by renting out their bike. For this they will need to add their own bikes to the Rebicycle system. However, regulations from the municipality forbid renting out assets in public places. Therefore, the owner of the bike needs to sell the bike to the Rebicycle network via the mobile app. By doing so, the owner of the bike will only be able to ride his/her bike if the bike is available in network just like all the other available bikes. In order to do so, the bike owner needs to make sure that his/her bike fulfills several requirements. If the bike is ready for use, a Lockchain lock can be ordered online by the Lockchain producers together with the Rebicycle sticker. For the lock, they first need to pay a price to ensure that the lock will be used for the Rebicycle system.

Once the bike is operational and brought to one of the hot-spots. As soon as another user wants to take the bike, the user will be asked to check if the bike fulfills the requirements and is operational. If this is indeed the case, the money for the bike will be transferred to the owner of the bike. If not, the owner of the bike will receive a request to check his/her bike in order to get paid. Now the bike is fully integrated into the Rebicycle system and will receive the same maintenance as the other Rebicycles. Every time the bike will be used a small percentage of the ride costs will be transferred to the owner of the bike. This means that the owner will earn money via sharing its asset in a legal way. The owner of the bike will always be up to date about the whereabouts of its bike and will always have the opportunity to buy his/her bike back from the system for the same price as it was sold for to the system. The availability of selling the bike to the system will depend also on the total amount of Rebicycles present in the city. City regulations will cause a maximum amount of bike-sharing bikes so this number can not be exceeded by adding personal bikes.

6.1.10 The ecosystem

As mentioned before in the parts about IoT, the ecosystem plays a large role in the success of these kind of products. Also in line with the CE philosophy it is important to understand what the relationship between different actors are and what benefits there are for each of these actors. Therefore, the design of an ecosystem is quite important to understand for these projects. With the Rebicycle concept, the whole operation even depends on the collaboration of different actors. To create a better overview of how this ecosystem operates figure 28 shows the risks and benefits for each actor and figure 29 illustrates the relationship between the various actors.



Actor

(General) User of the bikes

TradeFRM

Municipality

Bike Repair shops

City law enforcement

Citizens of Amsterdam

Bike owners that sell their bike

Lockchain Producers

DAO Creators
(Kryha or other Blockchain
developing company)

Benefits

- Mobility in the city
- No extra costs for owning a bike
- Extra income for transportation, costs and repairs
- Long-term customer
- Reduced amount of bikes in the city
- Mobility data available
- Voting power for changes in the system
- Bike removal expenses saved
- Extra work and income
- Easily re-park bikes by unlocking them with the application
- Less bikes misplaced due to the distribution
- More space to park their bikes
- Free bike rides available
- A direct purchaser for the bike
- Extra income generated by the bike
- Profit on the sold Lockchains
- Have a stake in the system which allows them to vote for changes in the system
- Can get rewarded for updating the system via Service Level Agreements (SLAs)
- Can be hired to make changes in the Blockchain

Risks

- Not available when needed
- Requires extra labor and employees
- Failure of this concept would cost money
- Profit margin might be lower than the usual margin for some bike repair shops
- Extra work to re-park bikes instead of just notifying the bike depot service
- More bike parking spaces claimed by Rebicycles
- Bike can be stolen
- Coin-price might drop and losses can be made

Figure 28. Actors in the Rebicycle ecosystem

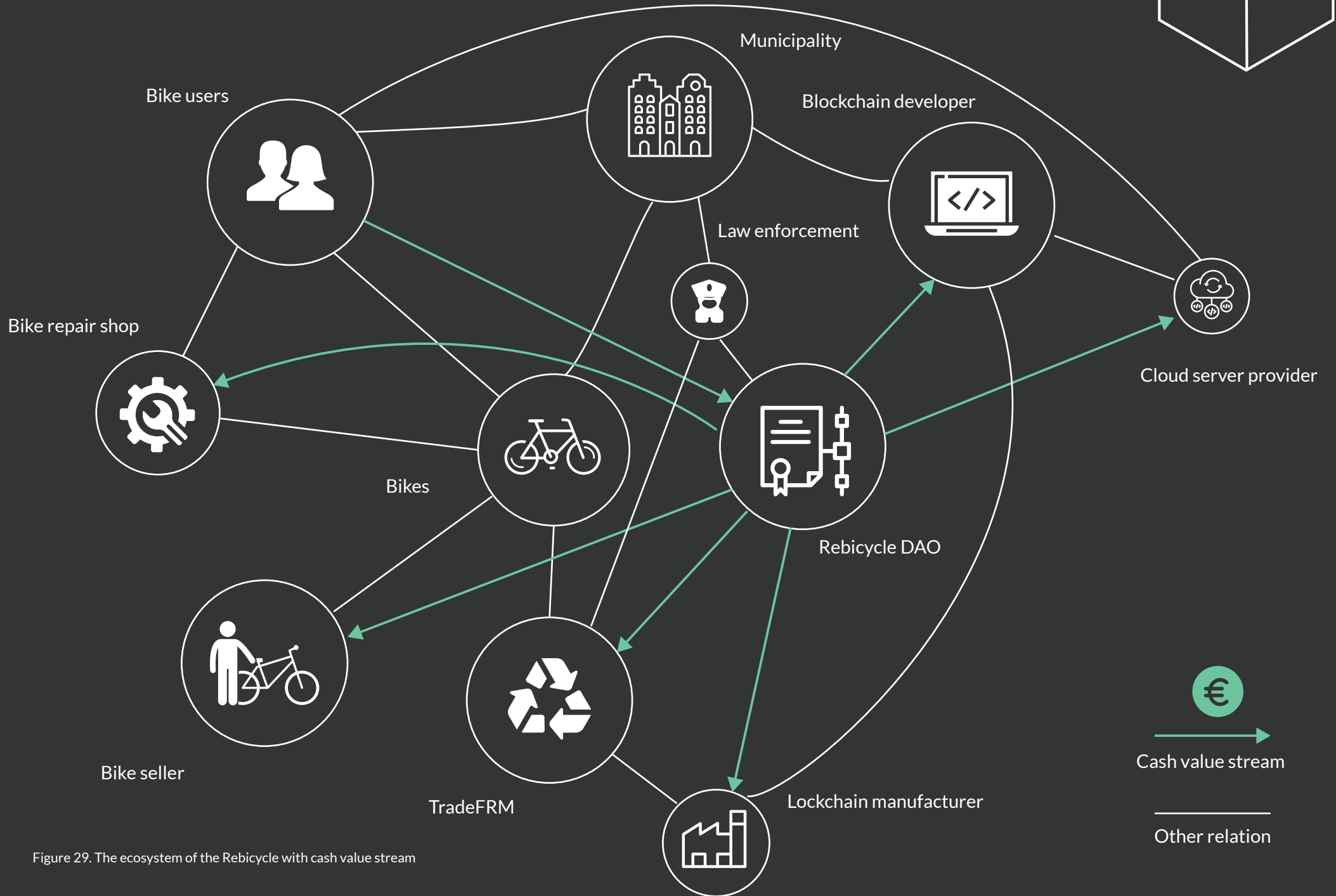


Figure 29. The ecosystem of the Rebicycle with cash value stream

6.1.11 Role of Blockchain

In this concept Blockchain plays quite a large role as an enabling technology. Although some of the functionalities could be created without the help of Blockchain, it certainly provides advantages over server based applications. Here are several advantages of using Blockchain in this system:

Security of transactions: Because of Blockchain, transactions between actors (e.g. the users and the municipality) can be made efficiently and without the risk of fraud.

Security of data: Due to the Oasis Blockchain, all data that requires full disclosure can be encrypted which makes it nearly impossible to hack. This makes it possible to deal with.

Distribution of data: The P2P node structure of the Blockchain technology enables all users that run a (light)node to be up to date all the time.

Security of the system: Also, due to Blockchain, the system is cyber-attack resistant which makes it nearly impossible to take the service offline.

No intermediary costs: In a normal server based service, transactions of money will be made via request to bank accounts to send money to the service providing party. Blockchain takes away the need for a bank as an intermediary for these transactions being done between actors. Also, actors in the system are capable of trading coins with each other without having to pay the DAO for intermediary costs. However, the DAO will need to store the money in a bank which was traded for the Rebicycle-coins. Also, the actors themselves will need to keep a bank account.

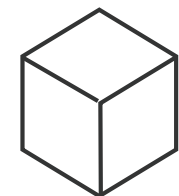
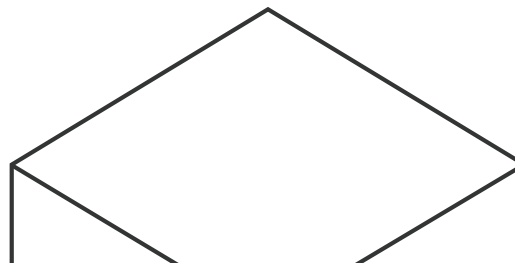
Trust between parties: The smart contracts in this system will remove the need for trusting the bike repair shops for fraudulent actions such as unnecessary repairs or to high declarations. All prices are set upfront and repairs only can be made if a different user requests this as will be stated in the smart contracts.

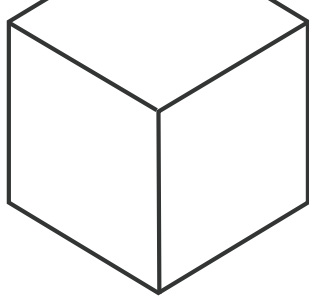
Low operational costs: The DAO requires fewer people to operate this system since the organization is operated automatically. This makes it possible to keep its pricing strategy low. Also, since a DAO is non-profitable, all profit made with the DAO will be reinvested in the organization.

Open for changes from the users of the system: A DAO is governed by the holders of the DAO's coins. Therefore, if the community of coin holders like to change something in the system, they are able to do so if a certain amount of coin holders agree. Only the biggest parties that have knowledge on how to vote in the system will be able to do so. Everyone who has a Rebicycle account will be able to buy these coins however, only Blockchain developers will be able to propose changes to the system. Therefore, it is most likely that the changes will only be proposed by parties that have invested a high stake in the system and have the knowledge to write a proposal.

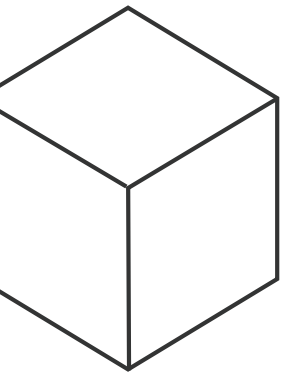
Easy transfer of data: Due to the distributed nature of Blockchain, all nodes and light-nodes that are part of this system will always be up to date.

Autonomous operations: The DAO is build to be always fully operational. The smart contracts of the DAO creates the autonomous operations of the DAO which makes the DAO predictable but consistent.





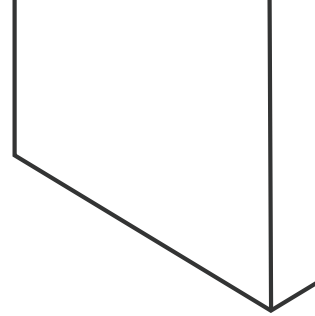
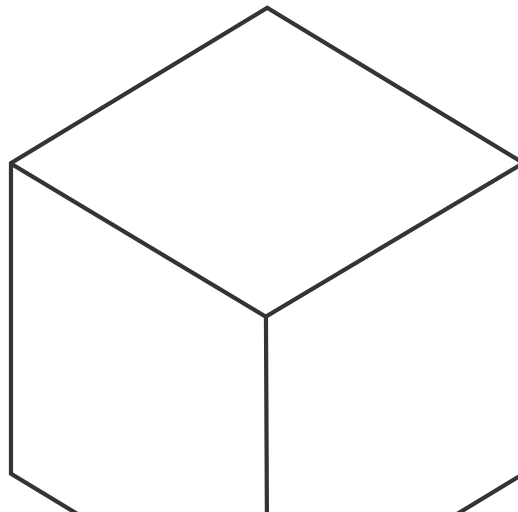
So it is clear that using Blockchain technology has multiple advantages for using it in such a system. However, why should this system make use of the Lockchain specifically? This has mostly to do with the level of security that is provided by the lock. Using Oasis Blockchain, makes it nearly impossible to hack the lock without the right key. The key, is only provided for the user who requests the key after payment. Furthermore, makes the Lockchain easier to be implemented in the DAO system and it can be used for the smart contracts of the DAO. For instance, the Lockchain could collect data from when the digital key is used to open the lock and when it is closed to see the time the bike is used. The time can be used in a smart contract that activates the transaction of coins to the DAO.



6.1.12 Smart contracts

6.1.12.1 Process

In previous parts it was mentioned several times that actions done by this DAO will be executed via smart contracts. The DAO essentially can be seen as only a stack of smart contracts on the Blockchain. As explained before in section 3.2.2.4, smart contracts are code that enable transactions to be done if a deal between the two parties was executed. These smart contracts require input in order to be executed. This means that a form of input should be provided by the system. In the Rebicycle concept, this will be done via the mobile application or the Lockchain itself. From the Lockchain the input that is collected is the identity of the Lock and bike itself and if the lock is opened or closed as was discussed in section 5.1.3.1 (figure 15). From the smartphone multiple inputs can be taken. For instance, the GPS location, time and user credentials. This data can be encrypted and stored in the cloud where it can be used as input for the smart contracts. For instance the GPS data could be used for checking if the bike is parked at a spot where it is not allowed and for which the user should receive a fine. How this action would be executed in the DAO can be seen in figure 31. Here it can be seen that the input provided by the Lockchain and smartphone are used for the smart contracts to be executed. Like this example, there are several other smart contracts that will operate like this.



6.1.12.2 Contracts for validation

One smart contract that was created for this concept is the smart contract for the bike repair shops. From personal communication with C. Kars (2019) information was learned that bike repair shops could be fraudulent with their repairs. To prevent this from happening, a smart contract will be made which states that only a bike can be repaired if a notifications about this broken bike was made by a personal account. In this notification, the user will state exactly what is broken and is able to provide a picture with this. If the bike is brought to the bike repair shop, the bike repair shop will only be able to get the predetermined amount of Rebicycle-coins if a repair to that part was done properly. To check this, the first user to ride the bike again will be asked if the bike shows any defects, if not, the smart contract will execute the transaction.

This will also work for TradeFRM. If the amount of bikes that are operational in the system drops below a certain number, a request for new refurbished bikes will be sent to TradeFRM. TradeFRM will prepare than a new batch of bikes and distribute them over the various hot-spots in the city. However, TradeFRM will only receive money for the bikes if the bikes are indeed being used in the system. Therefore, only if TradeFRM unlocks the bike at a hot-spot and takes a picture of the bike there, the money will be transferred to TradeFRM. In order for this to happen, the picture first needs to be checked by another user of the system. For checking the picture the user will be rewarded with a small amount of Rebicycle coins.

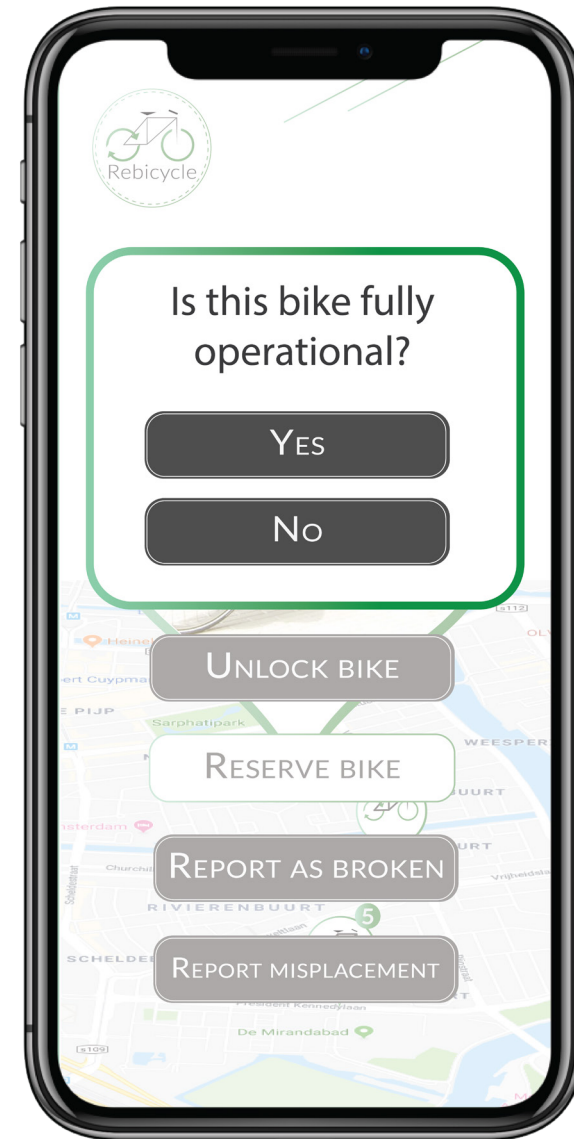
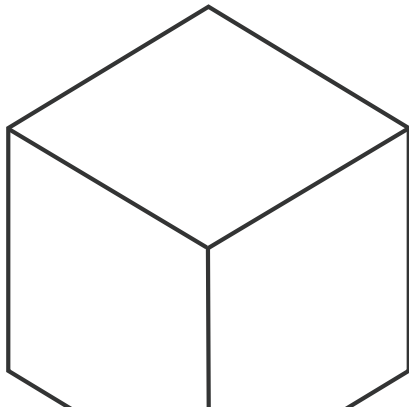


Figure 30. Validation question pop-up in the app

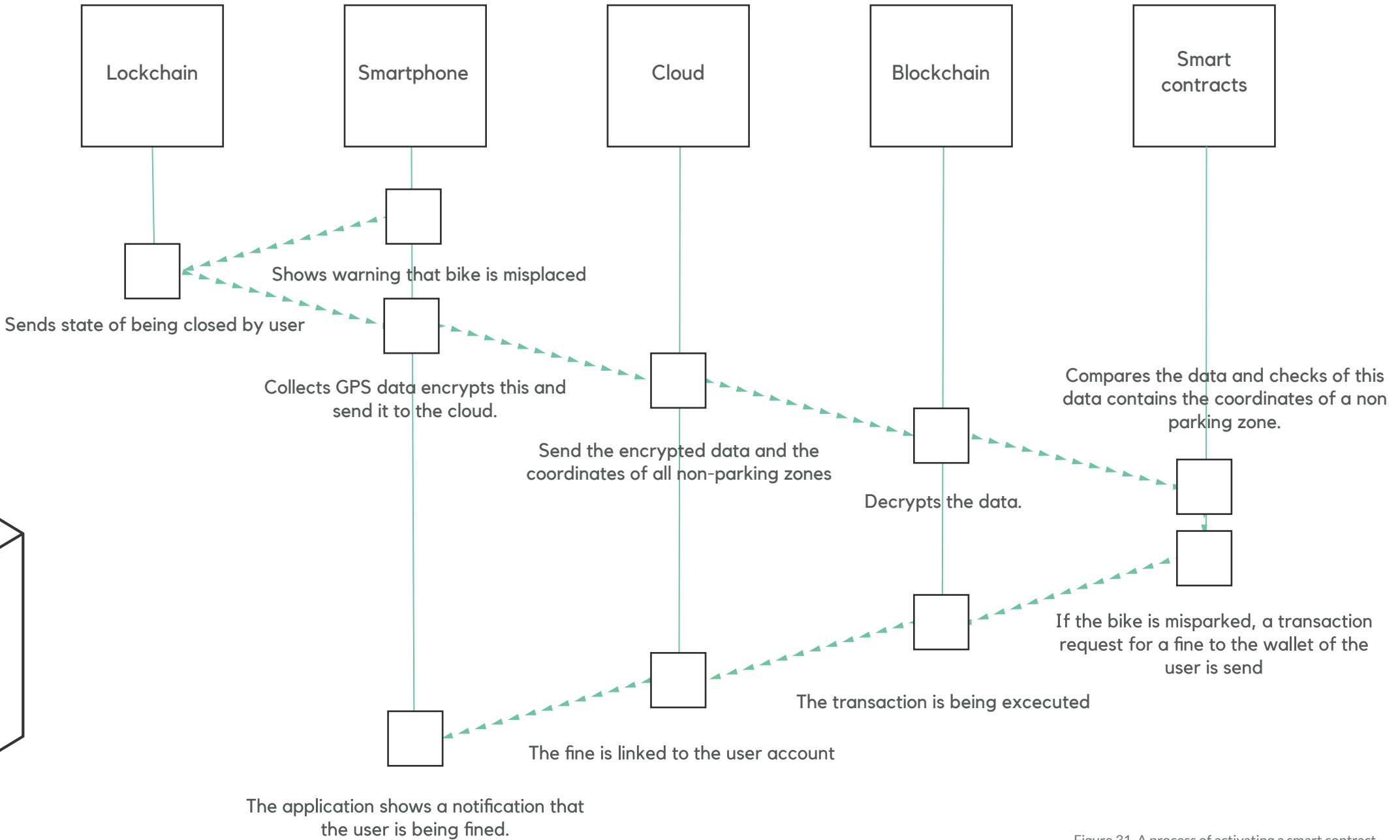
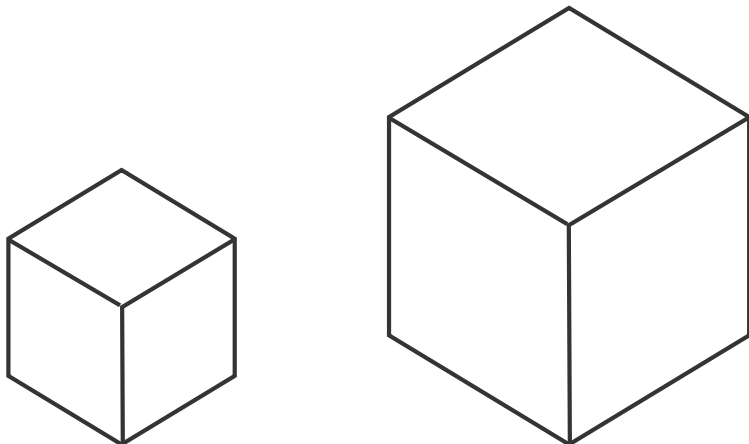


Figure 31. A process of activating a smart contract.

6.1.13 Governance and decision making

In general, the governance of a DAO is done by all the holders of a coin from the DAO. Coin holders are usually actors that provide funding to the DAO by investing in the DAO's cryptocurrency. The coins give the coin holders the right to vote for any changes in the DAO. Each coin holder could make a suggestion for a change in the DAO's code and only if the other coin holders agree, the changes will be applied. The more coins a party has, the higher the stake of the vote counts. In this way, the governance is being decentralized so there is not a central party that is in charge. This has been one of the challenges which asset-sharing services faces and in this way, the governance challenge is overcome.

In the Rebicycle concept, it is best if two parties have a stake in the creation of the DAO. First of all, the municipality of Amsterdam. By investing in this system, they contribute to a solution for the current bike problem. By investing in this system, they enable the system to exist and they have stake in how this system operates. However, in order to vote for the changes, the municipality will need to find a Blockchain developer that can write a proposal for the changes. A second party that should have a stake in the operation, is the developing party of the DAO. They are being paid by the initial investment in the DAO to be operational and they benefit if the DAO is successful. They could be hired to make the proposals for changes in the DAO by various parties so it is best if they also have a stake in the governance of the DAO.



6.1.14 Desired outcomes

With the implementation of this concept a few outcomes are desired. These outcomes are in line with the goals of the municipality and with the ideals of the Circular Economy.

Providing a clean mobility solution

By providing easy to use and widely available bikes the amount of people that take the bike instead of the car is desired to increase. By doing so, the number of cars on the road can decrease as well which would improve the mobility of the city by reducing traffic jams. Also by using a bike, the CO2 emissions of the trip will drop to zero.

Reducing the number of bikes

By the offering of free bike rides to the citizens of Amsterdam, the need of owning a bike should decline resulting in fewer people that stall their bike in the city. Also, all the time the bike is being used, the bike is not parked meaning that by encouraging people to use the Rebicycles, the number of bikes parked will decrease as well. This potentially could create more room in the now overcrowded parking places.

Stimulating local economy

The system offers local bike repair shops to do some of the repairs that are needed for the bike-sharing system. These repairs can be done in times when the amount of customers is little. This provides the local bike repair shops new ways to earn money. This can compensate for the loss of clients due to other bike-sharing services such as Swapfiets.

Providing a circular approach to bikes

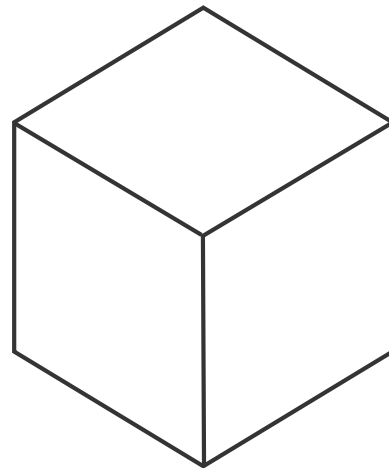
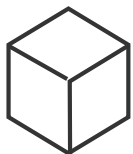
By refurbishing and recycling bikes and bike parts, the waste generated by this bike-sharing service is desired to be as little as possible in contrary to bike-sharing services such as Mobike and Swapfiets.

6.2 Evaluation

In order to check the possibilities of implementing the plan for the use-case, the concept was evaluated with several actors of the system. For this concept was evaluated on 3 aspects: Desirability, feasibility and viability. These three aspects were chosen as these cover the most important aspects for designing a concept design (IDEO, 2019).

6.2.1 Desirability

For the desirability of the concept, an actor of the ecosystem was interviewed. From the research done in section 5.1 the standpoints of the municipality were already discussed which showed what their need for the system was. The report on the needs from the citizens of Amsterdam regarding bike-sharing had shown what requirements were needed for the system to be desirable. Also, during the meeting with TradeFRM, a the first idea of having a circular bike-sharing service was discussed. In this discussion, the role of TradeFRM was discussed and this role was implemented in the final concept. The actor in the ecosystem that was not interviewed yet is the party that does a part of the repairs which is done by the bike repair shops. Therefore, a bike repair shop owner was interviewed to evaluate this concept. The setup of this interview can be found in section 4.4.1.



6.2.1.1 Changes in the business model

According to the bike repair shop, the work that would be provided by the Rebicycle concept would always be seen as an extra in their business model due to the fact that a large part of their clients are brought to them via word-spread and recommendations. The “real” clients will always have the priority. However, if the mobile repair shop is nearby a Rebicycle that requires a repair and the planning allows it, this would be time/cost effective for to repairman to fix the Rebicycle as well due to the reduced travel costs. Therefore, the mobile bike repair shop owner is willing to work on such a system.

6.2.1.2 Prices

The prices that the mobile bike repair shop asks are similar to the prices he would ask to other clients which are:

Fixing a flat tire	12,50
New inside tire	22,50
Loose chain	20,00
New chain	30,00
New front light	15,00
New back light	12,50
Both lights	25,00

All these prices include the VAT of 9% so the prices paid by the DAO if it is registered at the chamber of commerce are excluding 9%. Nevertheless, if the system would become a continuous stream of income for the company, the owner of the mobile bike repair shop would be open for creating a special pricing arrangement. (A. Uttenbos, personal communication, September 20, 2019)

6.2.1.3 Evaluation of the system

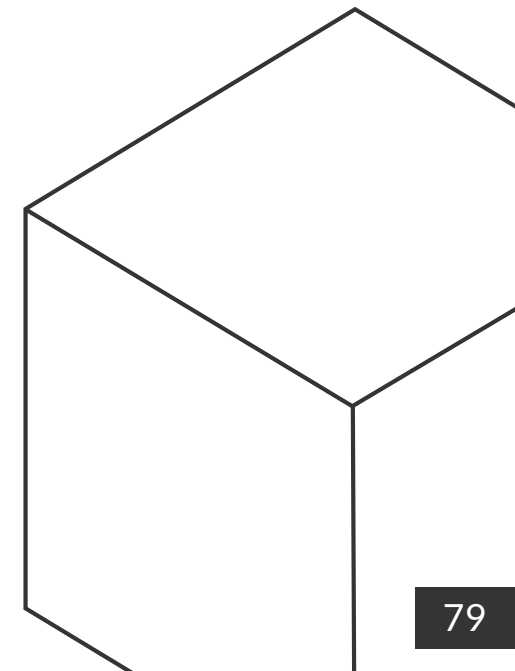
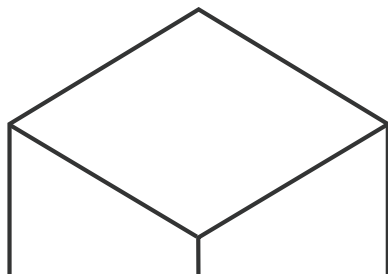
The mobile bike repair shop owner stated that three aspects were important for them to operate. First of all, the interaction with the app should be very easy to understand. Some of the employees of the mobile bike repair shop are not that good with smartphones and mobile applications which means that the user interface should be very clear with easy to follow instructions. The app interface shown to the bike repair shop (see figure 24) had already too many options and should therefore be simplified.

Second, the bike repair shop owner was not in favor of a special coin for the usage of the Rebicycle platform. For him it was important that after every repair that was made he could receive a receipt as prove that the repair was done for his own administration. If these receipts would only show the amount of Rebicycle-coins gathered via this repair, this would not be valid for his taxes.

At last, the bike repair shop owner had some remarks on the 3rd person validation method that was used to prevent fraudulent bike repair shops. He found this measure not necessary to have due to the risk of not being paid if the bike is being vandalized directly after being repaired without any other person using the bike. However, he did agree that there are bike repair shops that could act fraudulent. Therefore, he agreed with the function of only being able to repair what was notified by a user of the bike. (A. Uttenbos, personal communication, September 20, 2019)

6.2.1.4 Conclusion

The mobile bike repair shop owner would be willing to participate in this system as a backup for when no appointments are planned with other customers. However, in order to work with this system, the system should be easy to understand and should be able to provide receipts in euro for all maintenance that is performed. Furthermore, the method for validating the repairs is not ideal and should be changed in order to reduce the risks of not getting paid. These changes could be made in the further development of the Rebicycle concept. Therefore, the conclusion of the desirability evaluation is that the proposed Rebicycle concept is desirable to all parties involved.



6.2.2 Feasibility

Due to the immaturity of Blockchain technology it was sometimes difficult to validate that certain applications of Blockchain were applicable for this use-case via desktop or literature research. In order to finalize the concept several assumptions were made regarding the DAO and the hardware. To evaluate the feasibility of the concept and see if these assumptions were correct, the technical feasibility was discussed with a developer from the company Kryha. For this, the whole concept was explained to the developer to which he responded if certain aspects could not be done.

Interoperability between Blockchains not possible (yet).

In the design of the Rebicycle concept, the Lockchain is working via a Blockchain called Oasis. Oasis is a Blockchain that enables transactions to be non-disclosed which is good for providing the privacy to the users data on bike usage and location. Uport, a personal data storage tool, on the other hand is a Blockchain application layer built on the Ethereum Blockchain which can be used as a user identification tool since. Combining the users personal data with the privacy provided by Oasis could make a very secure way for the user to not only collect their own data in a encrypted manner, but also be in charge of what data they would like to share. Also, the use of Uport and Oasis could be used for making a person responsible for misuse without having to show in the Blockchain actually who that person is. However, from the interview it was learned that this would not be possible due to the fact that interoperability between Blockchains is not possible. Therefore, the idea of using Uport was canceled.

Machine Learning and DAO's are not operable yet.

In an ideal situation, the DAO would be able to apply machine learning to learn where the bikes should be redistributed based on relocations of bikes that were done before. This was included in the initial concept. However, in the interview it became clear that since the technology behind DAO's is still very immature, the combination of using Machine Learning in a DAO is still far from being developed. Therefore, this idea was left out of the final concept.

Benefits for the coin holders mostly consists of voting allowance.

Within the concept of the Rebicycle, the initial investment is done via an Initial Coin Offering. Holders of these coins are able to use these coins in the system but they also have another function. These coins are giving a right to vote for changes that are made in the DAO. Ideally, just as is the case with stakeholders in a company, it could be an idea to give a part of the profit made by the DAO to the coin holders. This would create another incentive for buying Rebicycle-coins and invest in the DAO. However, this is not usually done in a DAO. Profit made by the DAO could on the other hand be put in a treasury on which the coin holders decide what should happen with it.

Trusted developers are required for the governance of the DAO.

Also, in order to be able to vote, coin holders are required to have a certain knowledge level of Blockchain in order to know how this can be done. Also to propose a new change to the DAO, more advanced knowledge is required. This means that the parties that are involved in the DAO and possess coins, require the help of a Blockchain developer to work. This takes away a part of the value of having a decentralized platform since some actors will require a trusted third party in the form of a developer to work with.

Ride data should be sold by the user rather than by the whole system.

In the original business model of the concept, the DAO could sell the ride data of its users to a third party without showing any personal data. However, in a decentralized system, it is better to let the users be in charge of the data to enable them to share/sell their own data. This would create an incentive for the users as well to share their ride data. Therefore, it was implemented in the final concept.

The role of Lockchain could be replaced by other hardware.

The Lockchain itself would not be required for this system. If the Lockchain would be further developed the hardware protocols will be open sourced because of the Blockchain technology. People would be able to build their own smart locks to contribute to this system. Also other smart lock producers could implement the open source protocols to enable their locks for bike-sharing via this platform. These smart locks would then only operate as a gateway to the Blockchain.

Legal aspects are uncertain

Currently, there are no clear regulations yet on who is responsible for a DAO, therefore, from a legal perspective, DAO's are not ready to be implemented. Organizational aspects such as doing taxes or insurance are hard to apply to a DAO. Therefore, in order to implement a DAO like the use-case, first the right regulations should be in place.

In conclusion, the concept of the Rebicycle platform could be operational in theory. However, in practice there are a lot of technological difficulties in coding, that are out of scope of this project to research such a complex system for now. Nevertheless, in the near future, these kind of DAO's will be implemented and operational.

6.2.3 Viability

For the viability of the concept, a cost/benefit balance was created. In this financial overview the initial investment and other costs were calculated. This was done with the help of data required from the municipality reports and other desk research. However, most numbers are based on well informed estimated guesses. The full argumentation for this cost analysis can be found in Appendix C.

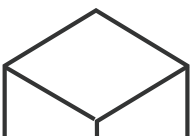
From the cost and revenue overview (Figure 32) it can be seen that in the end of every year, the profit projection is positive. However there are several aspects that are required for this projection to be true. These requirements are:

- Initial Coin Offering for covering the initial expenses.
- Enough monthly subscriptions of commuters for the full price.
- Enough monthly subscriptions of citizen frequent bike users.
- Low theft/vandalism rate.
- Low number of daily distribution required.

The estimated guesses for these posts were all based on reports. For the full argumentation for each of the cost posts, see appendix C.

Costs	Year 1	Year 2	Year 3	Year 4	Year 5
Rebicycles	150000	250000	0	0	0
Stolen / broken bike replacements	37785	107057,5	125950	138545	151140
Lockchain	210000	350000	0	0	0
Preparation costs	15000	25000	0	0	0
Stickers	750	1250	0	0	0
Initial distribution of the bikes	2100	3850	350	700	700
Daily distribution of the bikes	76650	217175	229950	255500	281050
Repairs provided by the mobile bike repair shop	18000	51000	54000	60000	66000
Repairs done by TradeFRM	6000	17000	18000	20000	22000
ICO launch	200000				
Development of the platform and application for the DAO	40000	0	0	0	0
Application maintenance	10500	10500	10500	10500	10500
Buying bikes from citizen	0	62975	62975	125950	125950
Citizen bikes fee	0	73000	146000	292000	438000
Rebuying Initial Coin Offering coins	0		600000	0	0
Total costs	-766785	-1168807,5	-1247725	-903195	-1095340
Revenue					
Montly subscriptions for half price	36000	108000	180000	180000	216000
Montly subscriptions for full price	432000	864000	1728000	1728000	1728000
pay-per use	15000	30000	33000	37500	45000
Fines	12500	25000	25000	31250	37500
Initial coin offering	617850	0	0	0	0
Total Revenue	1113350	1027000	1966000	1976750	2026500
Total Costs	-766785	-1168807,5	-1247725	-903195	-1095340
Cumulative profit	346565	204757,5	923032,5	1996587,5	2927747,5

Figure 32. Cost overview for the DAO (See Appendix C)



6.2.3.1 Expectations

While looking at this cost/revenue analysis, it can be seen that certain posts are decreasing over time while others are increasing. This has to do with the desired outcomes of implementing this system. These desired outcomes are the following:

Using peoples bikes rather than refurbished bikes: To reduce the number of bikes standing still in the city of Amsterdam, people are motivated to sell their bike to the Rebicycle network. To incentivize this, all previous owners are provided with a 0,10 euro fee for every time their bike is used. This would be better for the bike problem since the bikes owned by the citizens are currently causing the most problems (Gemeente Amsterdam, 2019).

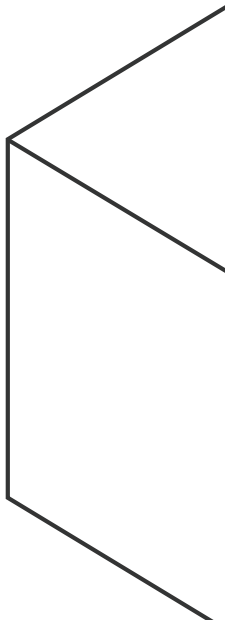
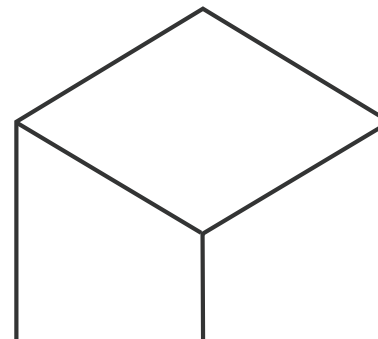
Reduce the number of theft and vandalism: By providing the bike for free and make people responsible for the bike, a drop in bike theft and vandalism will occur in a few years. This assumption is based on the fact that people will feel more responsible since they might have added their own bike to the system which would be more profitable if it was handled with care.

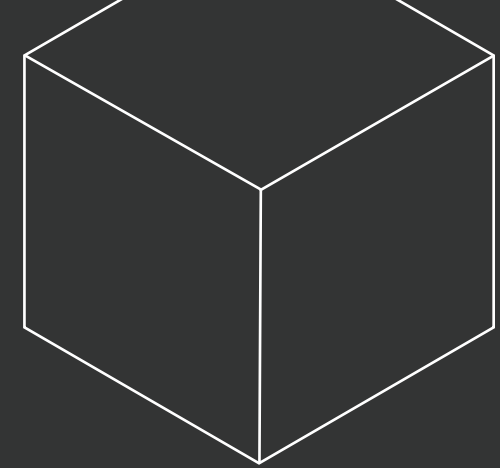
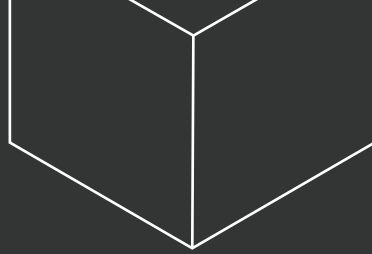
Lowering the prices for using the Rebicycles by enough profit: The DAO is a non-profit organization meaning that making the most profit is not the reason for creating the DAO. Therefore, if the amount of profit is high enough, the usage prices could drop so the end users of the Rebicycle system also benefit from the good results of the DAO.

Profit is invested in new DAO's: Even though the costs are quite high of this system, plenty of profit is generated by this DAO. This money on the other hand, could be used for creating more Rebicycle platforms in different cities. Therefore, the Rebicycle DAO will not require another ICO if other cities face similar problems.

6.2.3.1 Conclusion

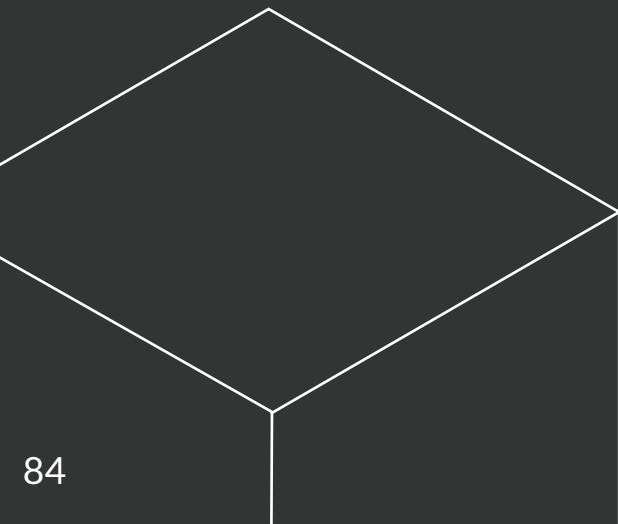
Although most numbers were based upon well informed estimated guesses. The system should be able to be a profitable system. Therefore, the conclusion would be that this concept is financially viable and could be implemented. However, in order to do so, clear agreements must be made with all involved parties. Also based on these agreements, a more extensive viability analysis should be done





7. Discussion

In this chapter, the use-case results will be discussed. This discussion will focus on the evaluation results of section 6.2 and on the research questions from section 3.3. This will be discussed in section 7.1. Based on this discussion, the final guidelines for designing a Blockchain based bike-sharing service will be created. These will be presented in section 7.2 and discussed.



7.1 Discussion on the use-case

7.1.1 The research questions

The purpose of the use-case design was to answer the research questions that were formulated after the literature research done in chapter 3. This section will discuss the answers to these questions based on the use-case. The first question is more focused on the role of Blockchain in a bike-sharing service whereas the second research question is more focused on the design

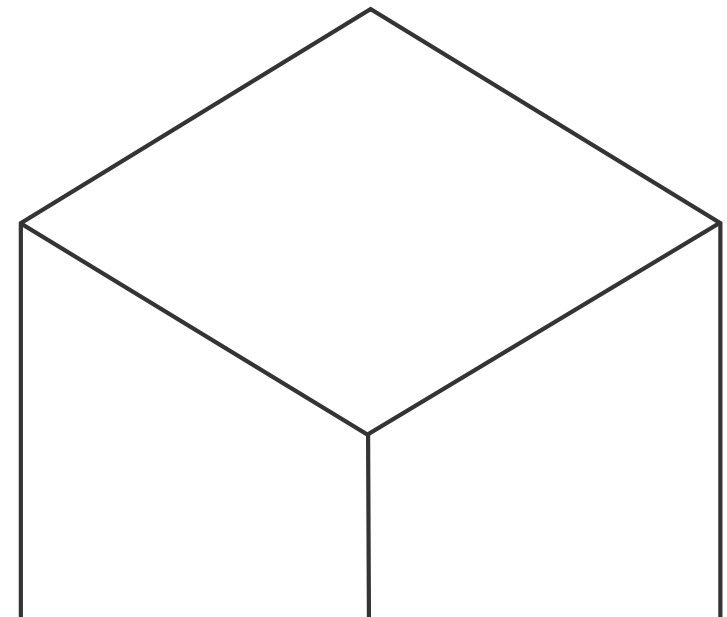
How can Blockchain be applied to bike-sharing services to help with overcoming the challenges regarding governance and trust?

- **How does Blockchain operate with IoT to solve these challenges?**
- **How is the role of Blockchain in the bike-sharing service defined?**

With the design of the use-case, it was illustrated how some of the challenges of asset-sharing services like bike-sharing could be tackled using Blockchain. By creating a DAO, the governance issues that are faced by companies like AirBNB and Uber are reduced since the governance of the system is done by the users of the system in a decentralized manner. This prevents the governance challenges stated by Ganapati & Reddick (2018) regarding the unfair pricing strategies or unfair wages. However, due to the immaturity of Blockchain and the limited amount of people that is able to work with Blockchain, the users of the DAO still require a third party in the form of developers in order to create changes in the governance. Therefore this third party could still be the cause of these challenges.

For the trust based challenges for asset-sharing as stated by Möhlman & Geissinger (2018) in section 3.1.2.3, Blockchain and IoT have shown the potential in this system to tackle these challenges and create more trust between the different parties from this system. Using smart contracts and a smartphone, a double validation option could be created which would make it harder for fraudulent parties in this concepts ecosystem to take advantage of the system by breaking and repairing the bikes for profit.

Overall the role of Blockchain in this system is mainly focused on the creation of the DAO and less on the usage of Blockchain in the Lockchain. Although the initial idea was to create the right context for the Lockchain, the focus moved more to solving the bike problem in Amsterdam with the use-case which resulted in creating a system that would technically not require the Lockchain to operate. Also, the initial idea behind the Lockchain was dismissed in this thesis because of several findings in the process. Nevertheless, the Lockchain would be a secure addition to the concept and would be capable of operating like a gateway for the Rebicycle Blockchain.



7.1.2 Designing Blockchain based bike-sharing services

How can a decentralized Blockchain based bike-sharing service be designed in a desirable, economically viable and technically feasible manner?

- What frameworks or methods could be used for designing a Blockchain based bike-sharing service?
- What are the requirements for a Blockchain based bike-sharing service?

To answer this research question, the use-case was evaluated on the aspects of financial viability, technical feasibility and desirability. From this evaluation it was seen that the concept was both desirable and viable. However, there were several aspects that will be needed to take into account therefore, these three aspects will be discussed.

Feasibility

The feasibility of the project is not sufficient at this moment. This has mainly to do with the immaturity of the Blockchain technology as was mentioned before. For using Blockchain as a decentralized bike-sharing platform, GDPR regulations make it hard to use personal data which is required for a bike-sharing service in combination with the immutability of the Blockchain. Furthermore, legislation around DAO's is almost non-existent which means that a completely decentralized bike-sharing platform could not be made from a legal perspective since this would require a central party to be responsible for the DAO. From a technical perspective, using Blockchain for a bike-sharing service to solve governance challenges would for now not be feasible yet. To allow all involved parties to have a stake in the governance of the system would require all parties to know how to propose changes to the DAO. This however, requires knowledge on how to set up requirements for these changes which is hard for the majority of the involved parties. Therefore, from both a legal perspective and a technical perspective, Blockchain is not feasible for being used in a bike-sharing service at this point.

Desirability

The concept can be seen as desirable from various actors in the concept ecosystem like the end-user, TradeFRM and the municipality. However, the desirability of the concept for the bike repair shops was only checked with one interview. This was due to the duration of the project and the unwillingness of several bike repair shops to cooperate. The interview done does however, give valuable insights in what a bike repair shop cares about and was therefore still useful to do. In order to validate the desirability of this concept, more interviews will be needed.

Also, several design decisions were now based upon the reports provided by the municipality of Amsterdam. These reports however, did only show the point of view of Amsterdam. The desirability for other municipalities in the Netherlands could therefore differ. Therefore, if this use-case would be used for other municipalities, more research on the desirability for that city should be done.

Viability

According to the cost estimation that was done in section 6.2, the concept would be a viable operation. However, there are several factors on which this is depending heavily. For instance, if the majority of the bikes will be destroyed without being used often, the operation will face losses which would mean that the DAO could no longer be operational. Also, for the financial viability, the initial funding for the DAO will come from an ICO. However, for this it was assumed that the municipality of Amsterdam would be willing to participate in this ICO and invest in this system. Therefore, their willingness to cooperate should be checked. Like this, there are more assumptions made based on reports that were found which should be discussed with the involved party in order to validate the viability of this concept.

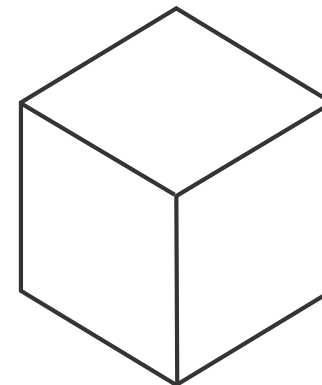
7.2 Guidelines for designing Blockchain based bike-sharing services

Methods

During the design of the use-case, several design tools were discussed and used. Eventually the ecosystem design canvas from Lewrick et al. (2018) was used for the creation of the concept. The canvas helped with creating an overview of all involved parties and created insights in the motives of each actor. This was very useful for identifying who would be influenced if Blockchain was used. However, this tool could be used for all kinds of products and services. Therefore, were some steps of the method more relevant for the use-case design process. Also, some steps could be added to this method to make it more useful for the design of a Blockchain based bike-sharing service. An example of this would be an iterative step in which the ecosystem is analyzed for Blockchain opportunities. This was done during the design of the use-case which lead to the insight of creating a DAO. Moreover, this step could also help with seeing that Blockchain would not be a good fit for a certain bike-sharing service.

For the identification of new Blockchain opportunities, the Blockchain identification framework and canvas from Klein (2018) were used. Although these tools were useful for the final design of the canvas, they both required more background knowledge to understand what these frameworks indicated if a Blockchain opportunity was found. For the design of a Blockchain based bike-sharing service, these tools could be redesigned in a way that it is more clear how Blockchain could be used in the situation of a bike-sharing service. Therefore, both tools that were used could be useful for the design of a Blockchain based bike-sharing service but they could be easier to use if they were designed in a way that they focus more on bike-sharing services.

In this chapter several guidelines are proposed for design cases similar to the use-case design of the Lockchain project that resulted in the Rebicycle concept. These guidelines are meant for concept designers of bike-sharing services that are willing to explore the possibilities of implementing Blockchain technology. These guidelines can also be helpful for already existing bike-sharing services that like to innovate in their current operations using this new technology. The guidelines contain 3 parts that propose tools to use for (re)designing an bike-sharing service with Blockchain technology enabled by IoT. Some of these tools were adjusted due to experiences from the design of the Rebicycle use-case and due to the research done before. Each part will also reflect on how these tools were used during the design of the Rebicycle. Furthermore, every part will contain a few takeaway tips that can be useful for the design of Blockchain based bike-sharing services.



7.2.1 Part 1: Defining the core value

Why:

The first step in creating/redesigning a bike sharing service is to understand the value the bike-sharing service can bring and why it is desired. With bike-sharing, the users of the bike are offered an outcome to a task that needs to be done by the user. For this, it is important for bike-sharing services to understand what the pains of the users are and how the provided asset can solve this pain. Also, with bike-sharing, people are moving away from owning a product that would normally solve their pains. To make this change desirable, it should be clear to the users what they would gain by using the bike-sharing system rather than buying the bike and owning it. The pains solved and the gains created by the bike-sharing service can be seen as a core value of the bike-sharing service. This is therefore the starting point for the design of these systems.

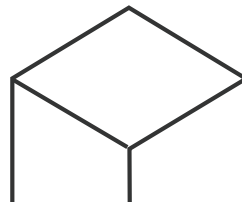
Tools used:

To create a clear overview of the users pains and what gains the bike-sharing service can provide, the Value Proposition Canvas from Osterwalder et al. (2015) can be used (Figure 33).

What needs to be done:

The value proposition canvas consists out of two parts. The customer segments and the value proposition. Each part is separated into three segments that need to be filled in. In the following part, each of these segments will be explained with a short example of a bike-sharing service. Later in this chapter, more detailed example will be given of how this tool was used in the Rebicycle use-case:

1. **The job to be done by the user** - These are the jobs that the user needs to do and can be seen as the requirements for the user. This can be either a functional job, an emotional job or a social job. A functional job for a bike-sharing service would be to get transported from place A to B. A social job would be to show that the user is environmentally conscious by going by bike instead of by car and an emotional job would be to use your body strength to move due to the feeling of exercise you receive from it.
2. **The user pains** - Pains are the negative outcomes and states of being our customers hope to avoid (Jeffries, 2019). For a bike-sharing service an example of this would be that there are no bikes available and that the bike could be damaged while using it.
3. **The user gains** - Gains are the positive outcomes and states of being our customers crave (Jeffries, 2019). The gains for a bike-sharing service would be, to be seen as environment-friendly, to arrive at the desired destination or to stay in shape while traveling.
4. **The bikes and services** - In this segment, the bikes and provided services are stated that can solve the customer pains and create customer gains. For a bike-sharing service this could be: an online bike-sharing platform, bikes, a redistribution service and an insurance policy.
5. **The pain relievers** - The pain relievers describe how the mentioned bikes and services can relieve the customers pains. For example this can be that the bike distribution service will ensure the availability of the bikes and with the bike insurance, the user does not have to worry about damaging the bikes.
6. **The gain creators** - These show how the bikes and services can create the positive outcomes that are desired by the user. For example, by using the bikes provided by the system, the user can cycle to their destination while working out.



Tips and Takeaways from the use-case:

A Value Proposition Canvas can be filled in for multiple parties. For instance, with P2P bike-sharing, it is useful to also create a Value Proposition Canvas from the bike owners perspective. This will give insights into the gains and pains of the bikes owner and why the owner would participate in such a service.

By finding more user jobs to be done, more pains and gains will be found that can potentially be solved by the provided bikes and services. Therefore, by identifying more jobs to be done, the value proposition will be more attractive for the end users of the system (Jeffries, 2019).

For bike-sharing, the need for owning a product needs to be overcome. Therefore the value proposition should show enough advantages to the user for using an bike-sharing service rather than owning the product. In the Rebicycle case this was done by making it financially more attractive and offer a wide availability of the bike.

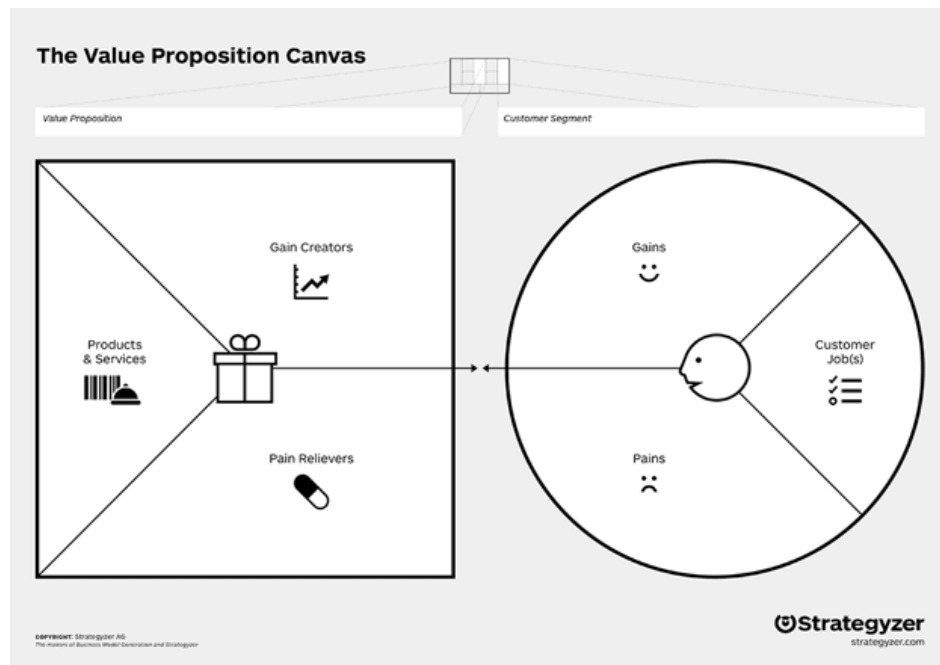


Figure 33. The Value Proposition Canvas (Osterwalder et al., 2015)

7.2.2 Part 2: Designing the ecosystem

Why:

With technologies such as Blockchain and IoT, the value of these technologies can be created by connecting different parties. For this it is important to understand the ecosystem of the bike-sharing system to see which actors are involved and what their connections to each other are. Therefore, to create/redesign an bike-sharing system, the ecosystem must be designed as well.

Tools used:

For the design of new product service ecosystems, the Business Ecosystem Design Canvas (BEDC) from Lewrick et al, (2018) will be used. However, due to the work done in part 1, the first step of the canvas has already been done. Also to implement Blockchain identification tools in this process, some steps of the BEDC will be done in part 4 of these guidelines.

What needs to be done:

For the BEDC, there are several steps to be made. The purpose of the canvas is to create a Minimum Viable Ecosystem. In order to use this tool, a large sheet of paper or white-board with markers would be useful. The starting point of the BEDC is defining the value proposition. This however, has already been done in the first part. From this starting point, the following steps are needed:

1. **Define all actors in the ecosystem** - These actors consist of all parties that actively participate in or with the bike-sharing service. For example, the ecosystem usually contain at least: the user, the provider of the bike, a distributor of the bike to the user, maintenance provider of the bike and a party that owns the bike-sharing platform.
2. **Map out all actors** - To create a visual overview, all actors are to be mapped out on paper. An example of how this would look can be seen in the use-case.
3. **Draw the value streams between the actors** - The value streams between the actors can consist out of monetary value, data or value in the form of outcome. An example of this could be that the user is paying the bike provider, filling in the users personal account data in the digital platform and the bike being repaired by a maintenance actor.
4. **List the advantages/disadvantages for each of the actors** - For each actor, analyze what the actor would gain from acting in this ecosystem and what the disadvantages are. For example, for a bike repair shop doing the maintenance for the bike-sharing service, getting more customers due to the bike-sharing service might be an advantage. However, if this means that he has to hire new employees to keep up with all the extra work this could be a disadvantage.
5. **Analyze the influence on the business models of these actors** - To understand the effect of the ecosystem on each of the actors individually, it is important to see how the actors business models might change by participating in the ecosystem. In the example of step 4 it can be seen that the business model of a bike repair shop can change because of their participation

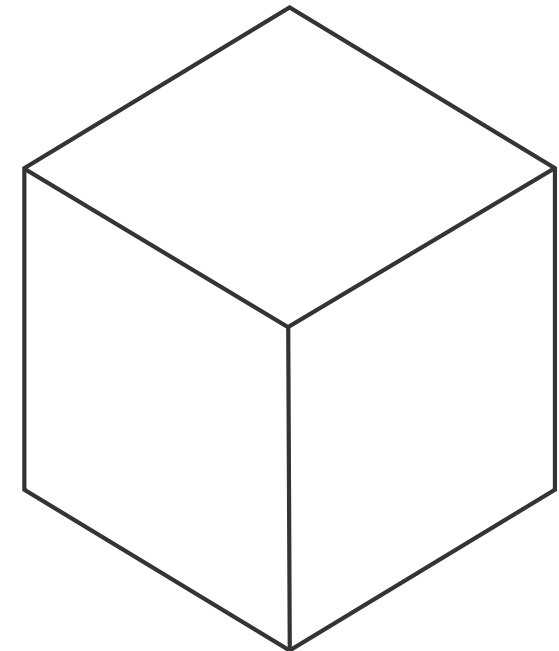
Tips and Takeaways from the use-case:

Make clear what type of value transactions occur in the ecosystem, this could make it easier to identify Blockchain opportunities in a later stage.

For bike-sharing services the following actors can be expected: End user, bike provider, digital platform provider, maintenance party, distribution party. These actors can be the starting point of the ecosystem to which more actors can be added.

The power from IoT comes from sharing data, therefore, make sure that all value streams include data that is provided by an IoT device.

As is the case with the VPC, the BEDC is also a dynamic tool that is created for iterative explorations. The result of part 2 is therefore not the final ecosystem design but more a platform to iterate on.



7.2.3 Part 3: Identify Blockchain opportunities

Why:

After designing the ecosystem of the bike sharing service and identifying and analysing the actors involved, the next step is to find out where blockchain can add value to the system. For this, the ecosystem map that was made in part 2 will be the starting point on which will be iterate

Tools used:

For the identification of Blockchain opportunities, the Blockchain use-case identification framework and Blockchain use-case canvas will be used. Both of these tools were proposed by Klein & Prinz (2018) in literature. However, based on experience with working with these tools and to make them more relevant for bike-sharing services, the questions these tools use were directed more into bike-sharing.

What needs to be done: Blockchain use-case identification framework

When taking the work done in the first two parts as a starting point, the use-case identification framework can be used to see if there is a possibility for Blockchain. First, the tool of the Blockchain use-case identification framework. The content of the original framework (figure 16) was reformulated to make it easier to apply to bike-sharing services. The framework contains 8 different questions that together form a checklist. The questions are divided into three different categories: Intermediary, data and process. For each of these categories, the ecosystem must be checked to identify if these categories are applicable. This framework can be used for several processes in the ecosystem, however, it is best to start filling it in for the core value proposition of the ecosystem.

The first category of the framework explores the existence and the role of intermediaries (figure 34). Blockchain can take over the tasks of an intermediary and could even completely act as an independent and incorruptible intermediary. Within this category, there are three scenarios: Replace, establish and adjusting business models. Whereas the first two scenarios are more relevant for anyone needing an intermediary for a use-case, the third scenario is relevant for anyone functioning as an intermediary in a use-case. Each scenario describes a specific situation and the user of the framework can decide which one, is applicable in the use-case (Klein & Prinz 2018).

The first scenario is about a situation where an intermediary is currently present as a third party that enables the connection between two or more stakeholders. However, the use of this intermediary might be time- or resource-consuming, or the process of interacting with other stakeholders through the intermediary could be inefficient or complicated. In this case, Blockchain technology can be used to save time, reduce costs or simplify the process. For example, while looking at one of the most famous asset-sharing companies currently active, AirBNB, the role of AirBNB can be seen as the third party that requires extra money for operational costs and profit.

The second scenario, establish, describes a situation where no intermediary is operating due to a lack of trust between stakeholders and potential intermediaries. Therefore the question is asked if there are actors in the ecosystem that can not be trusted. In this case, Blockchain can provide a safe and stable basis for transactions without needing the partners to trust a third party, instead they can trust technology (Klein & Prinz 2018). For bike-sharing this can be useful when there is no trust between the user of the bike and the owner of the bike.

In the third scenario, the perspective from the intermediary is taken. In this scenario the role of the intermediary can be replaced by Blockchain. In this scenario, the business model of the intermediary must provide enough benefits for the partners in the network to not be completely replaced by Blockchain. However, Blockchain can be beneficial for the business model itself (Klein & Prinz 2018). For instance for AirBNB, all-

services provided around the rental of apartments could be still done by AirBNB whereas the transactions could be done directly from user to owner via Blockchain.

Since these three scenarios show the different situations from different viewpoints, usually only one scenario will be rated as true (Klein & Prinz 2018). However, for different actors in the ecosystem the same framework could be used again. If no situation is applicable to the use-case, it might still benefit from Blockchain technology, but it is probably not crucial to the use-case.

The purpose of the second category, is to evaluate the use of data in the ecosystem. Blockchain technology offers the possibility to save data permanently and transparently as well as preventing anyone from modifying the data after it has been entered into the Blockchain. In this category, it should be analyzed how important the security and transparency of the data is. With bike-sharing services, data such usability and person information are not always desired to be transparent. However with the coming of Blockchain solutions such as Oasis, data does not have to be transparent to all parties. Also, if any form of offline value requires a digital copy is asked since this could enable the ownership of the bike to be traded over Blockchain. For bike-sharing services it the importance of security of data is more important in this framework.

In the process category, the possibilities for automation can be assessed. In the ecosystem, processes must be evaluated to see what could be automated via programmable smart contracts. These smart contracts will enable automatic transactions and could therefore be of use for transactions between users and owners in bike-sharing services.

Figure 34. The Addapted Blockchain Use-case identification Framework

<p>INTERMEDIARY</p> <p>1. Could the owning party of the bike sharing platform be replaced to reduce time, costs or simplify the process.</p> <p>2. Are there actors in the ecosystem that are not thrustworthy</p> <p>3. Could the owning party of the bike sharing platform adjust their business model to implement blockchain while not being fully replaced.</p>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
<p>DATA</p> <p>4. Is data collected by the bike sharing service?</p> <ul style="list-style-type: none"> - 4.1 should this data be immutable - 4.2 should this data be transparant - 4.3 Should this data be disclosed <p>5. Does any other form of data in the ecosystem require immutability or transparency?</p> <p>6. Does the bike require a digital copy.</p>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
<p>PROCESS</p> <p>6. Can processes of the bike sharing platform be automated?</p> <p>7. Can interactions with actors in the ecosystem be automated?</p>	<input type="checkbox"/> <input type="checkbox"/>

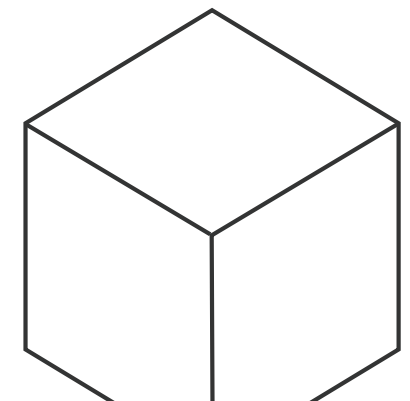
After the assessment of each category of the framework, it needs to be evaluated whether the bike-sharing service overall would benefit from Blockchain technology. Normally this would be the case if one scenario in the category intermediary is rated as true and the other two categories, data and process, are rated as important/ automatable (Klein & Prinz 2018). The more positively the last two categories are being rated, the more beneficial Blockchain technology could be. The evaluation of how much the use-case would profit from Blockchain can be assessed on a four point scale ranging from very to hardly. If several aspects of the bike-sharing service have been analyzed for Blockchain opportunities, it is best to start iterating with the aspect that would profit the most from Blockchain.

What needs to be done: Blockchain use-case canvas

Whereas the framework helps with identifying opportunities, users it is not presented yet how Blockchain exactly could be beneficial for the bike-sharing service. For this, Klein & Prinz (2018) proposed the Blockchain use-case canvas (figure 35). However, this canvas was also adjusted to make the canvas more relevant for bike-sharing services. This canvas enables the designer to develop deeper insights into how a suitable Blockchain would be structured. Additionally, it helps to identify the potential that could be unlocked by using Blockchain technology compared to the current use-case without Blockchain. Therefore, it works as an addition on the framework and designed ecosystem.

Within the canvas are five different categories that describe the relevant characteristics of Blockchain. The categories are: Added value, data and process integrity, decentral network, values in the system, and automation. For each category, all relevant aspects concerning this category in the canvas can be listed (Klein & Prinz 2018).

1. The first category, added value, it is listed what task/processes of the initial bike-sharing service are changed by implementing Blockchain. For instance, the transactions between the user and owner of the product.
2. Data and process integrity, the second category, identifies which data needs to be managed securely by the Blockchain exactly and how this data was collected. For instance, the personal information of the users of the bikes could be stored on the Blockchain..
3. The third category explores what other parties are connected to the Blockchains decentralized network. Also it asks who governs and supports the decentralized network. These can be found by looking at the ecosystem design and may include parties such as the distributors of the bikes or bike users.
4. In the values in the system category, the transactions that are being done via the Blockchain are analyzed. What do these transactions contain and what is their value? Also how this value is determined is asked. This value could for example be data, monetary value, identity, or a digital copy of the bike itself.
5. The last category is automation and describes which parts of the bike-sharing service case can be automated. It will describe what the automation holds and how it is used via the smart contract.



After having collected all relevant aspects in these five categories, a better understanding of how a Blockchain application would be structured for the specific use-case should have been achieved. The canvas enables practitioners to clearly see the benefits of Blockchain technology in combination with the specific use-case as well as to understand the different components of the Blockchain: Which data is stored on the Blockchain each time a transaction is being made, who are the partners who exchange transactions with each other, which values and rights are transferred by the transactions and how the creation of transactions or whole processes can be automated.

Tips and Takeaways from the use-case:

A DAO can be used to replace a central party. However, for creating a DAO it must be clear which parties will create the DAO and who will govern the DAO

Cryptocurrencies can be built to create value transactions via the Blockchain.

Via and Initial Coin Offering, an initial capital can be build which can be used for the first investments.

By letting the users of the bikes in charge of their own data, they can sell it if they like which will be an extra source of income for them.

7.3 Using guidelines for other asset-sharing services

The guidelines that were proposed to design Blockchain based bike-sharing systems are adapted especially for bike-sharing services. However, other types of asset-sharing, could benefit from this tool as well. The setup of an ecosystem for other asset-sharing services has many similarities to the bike-sharing ecosystem. Therefore, the tools that are proposed in the guidelines are capable of designing other Blockchain based asset-sharing services as well. However, more research for perfecting these tools for a wider range of products is required. Nevertheless, in this shape, these guidelines provide a good starting point for the design of new bike-sharing services and in combination with the use-case, it opens up new insights for the creation of new types of decentralized asset-sharing businesses.

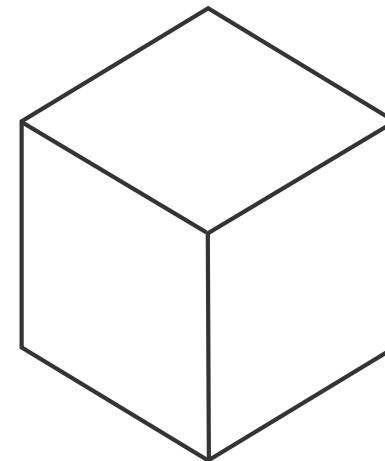
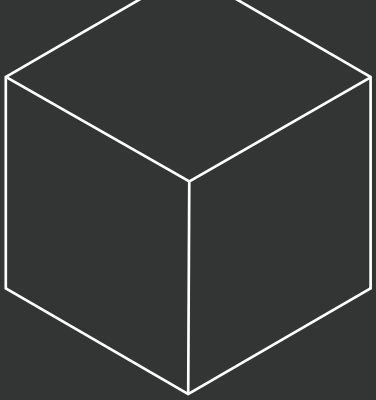


Figure 35. The Adapted Blockchain Use-case identification Canvas

ADDED VALUE	DATA	DECENTRALIZED NETWORK	VALUES IN THE SYSTEM	AUTOMATION
1.1 What tasks are changed by implementing blockchain.	2.1 How is the data collected?	3.1 Which actors are connected with the decentralized network?	4.1 What value is used in the transactions?	5.1 What processes will be automated?
1.2 What processes are being improved?	2.2 What data requires security?	3.2 Who supports the decentralized network?	4.2 How is this value determined?	5.2 What will the smart contracts look like?
1.3 What unique characteristic is being achieved (e.g. Trust between actors)?	2.3 What data requires transparency?	3.3 Who governs the decentralized network?		
	2.4 What data requires disclosure?			



8. Conclusion

In this project the way Blockchain and IoT could be used for bike-sharing services was researched via a use-case. For this it was found that Blockchain technology has the potential to solve challenges of bike-sharing services regarding trust and governance. Due to the ability to use smart contracts in a Blockchain, a decentralized autonomous organization (DAO) could be created. This DAO is controlled by all holders of the DAO's coin which creates decentralized governance. Via the smart contracts and third person validation methods, trust between the different parties can be established. While evaluating the use-case it was found that a system like this still has several burdens regarding its feasibility. So is working with a Blockchain based system like this not user friendly and it requires a Blockchain developer to propose changes in the DAO. On the aspects of desirability and viability, the use-case concept was found to be both viable and desirable.

Based on the design process of the use-case, several design guidelines were created. These guidelines could be used by existing or new bike-sharing services, to analyze and design Blockchain opportunities in a bike-sharing service. These guidelines are based on the value proposition canvas (Osterwalder et al., 2014), Ecosystem design canvas (Lewrick et al. 2018) and the Blockchain identification framework and canvas (Klein & Prinz 2018). These guidelines could potentially be also used for other asset-sharing services though more research must be






9. Reflection



Research struggles

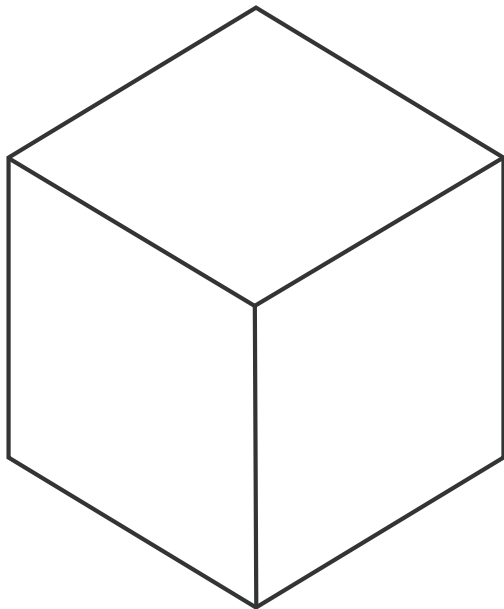
Within this project, I challenged myself by working with very new subjects that are still under heavy developments. Working with Blockchain meant that there was a limited amount of literature and use-cases available. Although Blockchain has been around now for a decade, new ways of using this technology are found every month. This has resulted in many emerging startup companies that all make promises of what their type of Blockchain is capable of. Nevertheless, many of these companies fail before being launched meaning that you can not use their offered possibilities for the design of a concept since it is unclear if these possibilities are feasible. Moreover, most information about the possibilities of these companies is only provided by the company itself. This means that the available information on these possibilities is often biased and limited. This was one of the burdens I faced during this project. However, due to the connections to the Blockchain society which some of the employees of Kryha had, they could help me with providing more information on what could be done, what could not be done or what could be done in the near future. Therefore, I was happy to be able to work every week at the Kryha office so I could easily discuss any problems.

Another point that slowed down my process in this project was the unresponsiveness of several parties that I reached out to for help. I have tried for multiple months to get an interview with a policy maker from the municipality of Amsterdam without any luck. Also with the help of my professors at the university this did not happen. Therefore, I had to make a lot of assumptions regarding the desirability of the municipality based on the reports from the municipality that were available online. Nevertheless, in order to validate this desirability, more contact with the municipality is required. However, due to this lack of cooperation, it challenged me to access the required information via other ways from which I learned to adapt to these kind of situations.



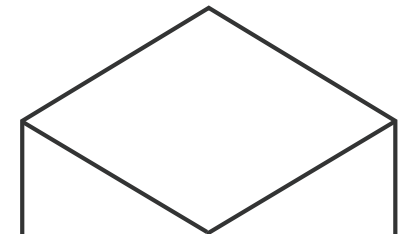
Documentation

One of my goals that were stated at the beginning of this project was to stay up to date with the documentation of my work. Although I managed to write down all my findings, it took me way more time than I had planned for this. This caused me to fall behind on my documentation halfway through the project which meant that I was not able to show what I had done to my supervisors. This meant that during the meetings I had with my supervisors I could not discuss all the things that I had done since they were not able to read it as it was not written down by me. I think this has led to confusion over what I was doing for both me and my supervisors. Nevertheless, in July I made an overview of what was done exactly and how this had influenced the further process. This had helped both my supervisors and me to understand what I was doing and why. In future project, more time must be planned in for the documentation as I now overestimated my own working speed.



Implementing both masters

I had chosen this project because it offered me to do my graduation for both SPD and IPD. In the initial plan, for SPD a framework would be developed for the implementation of Blockchain based bike-sharing services and for IPD a concept around the Lockchain would be developed. Throughout the project it became more clear that the value of my thesis for the companies would come mostly from the results of the framework and not so much from the Lockchain. Kryha, X.bike and TWTG did not show any intentions to actually produce and use the Lockchain but were mostly working on it to learn from its development. Therefore, they gave me the freedom to step away from the Lockchain if necessary. During the project I found multiple reasons to change directions from the initial plan of the Lockchain and focus more on the opportunities that Blockchain could provide to a bike-sharing service. This however did also mean that I focused more on the use-case concept from a strategic point of view rather than focusing purely on the product itself meaning that this project ended up to be more in the area of SPD than IPD. Nevertheless, a part of IPD is also to be able to work with new technology and design and conceptualize product services using this technology which was definitely done in the use-case by the design of a DAO service system. Therefore, I feel that this project has shown my skills to conceptualize new technologies into product service systems as well as designing a strategy for this concept and thus showing that I am capable of working on both IPD and SPD projects.



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B: Market Research

	Mobike	OV-Fiets	Urbee	Swapfiets	Hello Bike
Key-value	High availability and low prices	Located near stations which are perfect for the last mile problem	Offer a solution for trips from 0 - 20kilometres	Provide rented ownership of bikes without the care of maintenance	Provides mobility solutions for companies
Target Group	Travellers, Students	Travellers	Home-Work travellers	Students	Employees of companies
Type of Bike sharing	Free Float bike sharing	Docked Bike sharing	Docked bike sharing, Swapping bikes	Swapping bikes	Docked bike sharing
Type of Bikes	standardized bikes	standardized bikes	standardized electric bikes	various standardized bikes	standardized bikes
Docking station	No, but there are allocated Mobike stations	Only at the stations where they can be rented	yes, here the bikes must be brought back to the same docking station after being used	No	Yes, the bikes must be brought back to one of the docking stations
Business model	Subscription, pay-per-ride	Subscription, pay-per-Ride	Subscription, pay-per-ride	Subscription	Subscription for companies only
Usage	Incidental use and daily use	Incidental use and daily use	Daily use but incidental use possible	Daily use	Daily use
Prices	1,50 euro per 20 min 12 euro per month	3,85 euro per 24 hours	99 euro per month 0,05 euro per minute, 3 euro for the first hour, 15 euro per day	15 euro per month, 12 euro per month for students	unknown
Maintenance	Done by Mobike or thrown away	Done by OV-Fiets	Done by Urbee	Done by Swapfiets and various bike repair shops	Done by bike repair shops hired by X.Bike
Pick up points	At Mobike parking hotspots or within a predetermined area	At a train station	At various Urbee docking stations	Brought to your home or collected from various Swapfiets repair points	At the X.Bike docking stations
Mobile Application	Yes	Yes	Yes	No	Yes
Personal Data	Yes	Yes	Yes	Yes	No, only company data

Bike characteristics	sturdy, orange wheels, front basket	sturdy, yellow and blue frame	Sturdy, Red wheels	Blue front tire, different color combinations possible	Sturdy, red frame
Lock type	Bluetooth Lock	Regular key lock with GPS in Key hanger	Bluetooth Lock	Regular key lock with extra chain	Bluetooth Lock
Personal bike	no	no	yes	optional	no
Old/broken bikes	Thrown away	Recycled and refurbished	Unknown	Striped for parts and thrown away	Recycled and refurbished
Fines	Yes for misplacement	Yes, for vandalism, theft and returning the bike to different locations	Yes, for vandalism, theft, not locking the bike properly, not parking in a docking station	Yes, for vandalism, theft and misplacement.	Yes, for theft and vandalism
Relocation of bikes	Done by Mobike	Done from station to station by OV-Fiets	No	Bikes are collected by a car when the subscription ends	No

C: Cost analysis argumentation

Costs

Rebicycles

For rebicycles, a cost price of 50 euros was used. This is the price that TradeFRM asks for these bikes (C. Kars, personal communication, April 23, 2019). According to the report by Gemeente Amsterdam (2019) until 2021 only 9000 bike sharing bikes are allowed. To not overflow all bike parking places, a distribution was made of 3000 in year 1 5500 in year 2 and 500 in year 3. in year 4 and year 5 more bikes can be added. In total around 36.000 bikes will be needed according to Lam et al. (2018). Nevertheless, this number will not be reached in the first 5 years due to regulations.

Stolen/destroyed bike replacement

Unfortunately, bike sharing bikes will get stolen. However with the identity of the users known, the percentage of bikes stolen or destroyed beyond repair will be around 10%. These bikes will be directly replaced by TradeFRM. The costs in the overview are the results of 10% of the total bike fleet times 125,95 euro which include the costs for a bike (50 euro) with a lockchain (70 euro), sticker (0,25 euro), preparation (5 euro) and distribution costs (0,70 euro)..

Lockchain

For every bike that is distributed, a Lockchain is needed. According to kryha (2017) the cost price of the Lockchain should be estimated on 70 euro.

Preparation costs

Every bike that is placed in this system requires an employee of TradeFRM to place a sticker on the bike and instal the Lockchain. This will cost around 5 euro per bike. This number was estimated by taking 15 minutes per bike for labour costs of 20 euro per hour. (C. Kars, personal communication, April 23, 2019)

Stickers

The stickers cost 0,25 euro per sticker (drukland.nl, 2019).

Initial distribution of the bikes

All the bikes that are bought from TradeFRM or from the citizens of Amsterdam, must be distributed over the bike parking hotspots in the city. This initial distribution costs 35 euro per ride. Every ride, 50 bikes can be brought along (C. Kars, personal communication, April 23, 2019).

Daily distribution of the bikes

Whenever there are to many bikes at a certain hotspot, TradeFRM will send a truck to drive redistribute the bikes. It is estimated that around 10% of the bikes will need to be redistributed daily. The costs of this distribution are similar to the costs of the initial distribution.

Repairs provided by the (mobile) bike repair shop

It was estimated that around 30% of the total bike fleet will be in need of a small repair which can be provided by a (mobile) bike repair shop. The average price of a repair is said to be 20 euro based on the frequency of the different repairs. (A. Uttenbos, personal communication, September 20, 2019)

Repairs done by TradeFRM

An estimated 10% of the total fleet will require new parts or other repairs that are done by TradeFRM. Each of these repairs will take approximately 1 hours which means that each repair costs around 20 euro.

ICO

According to Lielacher (2018) setting up an ICO will cost around 250.000 as a minimum. Since this system is not aimed at a large public and will not require much marketing costs and mainly development costs this number is brought back to 200.000. This money must be lend from an investor and should be repaid as soon as the ICO has generated enough money.

DAO application and platform development

According to the company appinventive (2019) a blockchain application

from this size could be build for 25.000 euro. Based on Lielacher, the development of a blockchain platform like this is around 15.000, so, an estimated 40.000 was taken as development costs.

Application maintenance

According to Chomko (2012), the maintenance of the application will cost around 20% of the initial development costs which results in 8000 euro. These costs will also include the storage on the cloud servers. The cloud servers will cost around 2500 euro per year (Microsoft, 2019).

Buying bikes from citizen

When this system is launched, people from Amsterdam will be offered a free transportation option via the rebicycle system. If these people are in possession of a bike and do not longer use this bike, they could sell the bike to the rebicycle system. For this, they will receive 50 euro and a small fee of 0,10 euro for every ride that is made with the bike. The bikes will be prepared by TradeFRM with a sticker and the Lockchain (125,95 euro in total per bike).

Citizen bikes fee

According to Lam et al. (2018), every bike sharing bike is used 4 times every day. Therefore, people that sold their bike to the system earn around 0,40 euro per day in rebicycle coins. The total fee is 0,40 euro times 365 days times the total amount of citizen-provided bikes.

Rebuying the ICO coins

Once the DAO is profitable, this profit will be used to pay back the invested coins that were sold during the ICO. This will make it more attractive to invest in the system during the ICO. However, for governance reasons, not all coins will be bought back.

Revenue

Monthly subscriptions half price

The majority of the users of the rebicycle system will exist out of citizens

of amsterdam that can ride the bike for free. Nevertheless, some of them will make use of the subscription option so they could use the bikes for longer trips to work. Therefore it was estimated that around 500 people in Year 1 will make use of this. In the years to follow, this number will grow due to the increasing availability and the habituation to the system.

Monthly subscriptions full price

As Lam et al. (2018) described, there is a large need for bike sharing bikes, especially from people that do not live in the city. This is approximately 33% of all bike sharing bike users. Based on the 36.000 users as was estimated by Lam et al. The total number of users should increase to 12.000. It is estimated that this number will be reached in year 3.

Pay-per use

Tourist and incidental users will pay for just one short ride. The number of rides per year are estimated based on the available bikes and the amount of subscription users.

Fines

The average fine costs 12.50 euro. The amount of fines is highly dependent on the mentality of bike sharing users. This number is estimated to be a 1000 fines in the first year. This number will be growing in the following years since there will be more users to be fined.

ICO

The Initial Coin Offering income is the amount that would be needed for establishing this system. This amount is the sum of the first batch of prepared and distributed bikes, Lockchains and stickers. Also, this number includes the costs of the ICO launch and the development of the app/ blockchain platform.

