Seminar Thesis

MobChain

The Future of Mobility

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Chapter 1

Introduction

This report outlines the work that has been carried out in the framework of the BIOTS - Blockchain and IoT School at ETH Zurich 2018. The school has the goal to push education for innovative new technologies into universities and to help Switzerland to become one of the leading hubs in Blockchain and IoT space. After participating in different lectures and hands-on workshops a Hackathon is carried out to develop business concepts using blockchain technology extensively. In the following, we will introduce and discuss our business concept.

1.1 Justification

In the olden days, the taxi and car rental industries were organized by fragmented switchboard operations and complicated booking systems that required a lot of manpower. Over the past two decades inventions such as mobile internet and smartphones were introduced. These inventions paved the way for mobile and web applications such as Uber or Mobility that revolutionized the taxi and transportation industry. Uber disrupted the traditional taxi market by simplifying the process of catching a cab. Due to the simplification of the process of ordering a cab lower prices are feasible which is one of the unique selling points of Uber. Mobility is a carsharing platform that makes it easy to rent a car for a short period of time at a lower price than conventional car rentals. Moreover, unlike traditional car rentals, car sharing companies like Mobility make it unnecessary to personally own a car.

However, time does not stop and the recent developments and improvements in the blockchain world do offer opportunities for even more radical transformations of the taxi industry and the transportation industry in general.

The two main drivers of success of companies like Uber and Mobility compared to the outdated taxi and car rental business models are increased convenience and lower prices. We from MobChain have found a way to use the distributed ledger technology (DLT) in order to revolutionize the transportation industry even more fundamentally than Uber, Mobility and others.

A lot of people think that the blockchain technology can only be used for creating cryptocurrencies but this is a big misunderstanding. In this report we will show that applying the blockchain technology to the transportation industry can reduce prices and increase the convenience level even more than the above mentioned innovations. When using the blockchain technology, platform providers like Uber or Mobility would be superfluous; blockchain will bring car owners and passengers, i.e. supply and demand, together and will create trust between the contracting parties through its unique architecture (Zpunkt (2016)). Moreover and more importantly we introduce a feature that motivates people to drive eco friendly and that reduces the amount of cars that are needed to satisfy the needs of the entire population. We from MobChain think that this feature will mark a milestone in the process of sustainable and social transportation. Before getting into detail of our solution in Chapter 2, in Section 1.2 we give an overview on how other tech companies use blockchain, internet of things (IoT) and artificial intelligence (AI) to revolutionize the transportation industry.

1.2   State of the Art

Until today there are several technology startups that are dedicated to developing new possibilities to revolutionize the way we are moving from one place to another. By fundamental advances in the fields of blockchain, internet of things, artificial intelligence and the handling of big data new tools for reaching this goal have been established. In the following section a short overview of different companies aiming this goal is presented.

La'Zooz The Israel based startup has the goal to establish a decentralized transportation platform owned by the community. Their platform is able to synchronize empty capacities in e.g. cars with the transportation needs of others in real-time. By using cryptocurrency technology La'Zooz works with a "Fair Share" rewarding mechanism for users offering their car seat and customers using the offered transportation service. Developers and backers are rewarded with La'Zooz's cryptocurrency for their contribution to developing this platform (La-Zooz (NA); Dahlmann (2016)).

Commuterz The Peer-to-peer mobility service has the goal to enable trustless collaboration using blockchain technology extensively. The early stage startup from Israel has the goal to establish a carpooling service that enables non-trusting partners, like Original Equipment Manufacturers, big employers and other carpooling service providers, to fit their mobility needs. Using a token with real life value that costumers can use for mobility services the idea steps into the monetary world Commuterz (NA)).

Darenta Darenta is one of the most advanced companys in the field of combining blockchain technology and carsharing. The company from Russia also has the goal to establish a car rental service for owners who rent out their private cars. On this platform, any person or company can rent cars with insurance using smart contracts implemented in the Ethereum blockchain. Social carsharing works without a commission for car owners. Users can rent a car for a cost specified by the owner of the car. Car owners earn money while renting out their personal car. Conversely users who want to rent a car get access to a lot of vehicles (Darenta (NAb,N)).

Arcade City The US-american technology startup has the goal to offer a alternative to the established ridesharing services as Uber and Lyft. They offer the possibility to pay the driver directly using peer-to-peer technologies like credit cards, PayPal and Bitcoin. Furthermore, they also give the opportunity to pay for the service using a free of charge gamification approach based on specific votings (ArcadeCity (NA); Hüfner (2016)).

Tesseract   The multinational professional services company EY launched a
company called Tesseract that is dedicated to build up an integrated mobil-
ity platform powered by blockchain technology. Similar to the other mentioned
projects a platform has been established that offers fractional vehicle ownership,
shared use and seamless multimodal transport. The future goal is to lay a foun-
dation for how autonomous vehicle fleets can be owned in the future and provide
access to a variety of on-demand mobility options (Ernst and Young (2017)).

Others   Different companies are trying to push blockchain technology in in-
creasing parts of our daily mobility. For example ZF, UBS Bank and Innogy -
part of RWE's Innovation Hub - have the goal to establish automated transac-
tions for gas or electric power for charging managed by the car itself. Cooperat-
ing with the startup Slock.it an e-wallet for every car is implemented (Dahlmann
(2017)). The swiss insurance company AXA partners with AdNovum, the Uni-
versity of Zürich, AMAG, Mobility, Lucerne University of Applied Sciences and
Arts and the road traffic licensing department Aargau to develop a car dossier
which collects all relevant information of a car's life cycle using blockchain. This
information concerning the state of a car can be used by the manufacturer, the
insurance company and other involved partners (Ade (2017)). Furthermore, the
Toyota Research Institute (TRI) collaborates with different partner institutes to
help its vehicles provide more value to owners by enabling seats, trunk space
and other unused but potentially valuable resources to be monetized (Richmond
(2017)). The objective is to create transparency and trust among users to reduce
risk of fraud and reduction or elimination of transaction costs using blockchain
(Hanson (2017)).

Chapter 2

Challenge and solution

2.1 Current challenges faced by mobility

It is widely accepted that there is still much room for improvement concerning the transportation of people in and around the cities all over the planet. One of the major problems is that there are too many cars located and driving in cities which causes traffic jams although people could often switch to public transportation. The next problem follows directly from the last one. The traffic jams lead to higher fuel consumption of cars driving in cities. As the reduction of the carbon dioxide emissions is one of the major duties in the world of today it is absolutely necessary to reduce the amount of cars driving in cities. People should be rewarded if they avoid taking their cars to cities.

Another problem arises because people do not consequently use the seating space which their cars offer. Often there are only one or two passengers per car. This leads to a great waste of fuel and also to congested roads. Furthermore the fact that todays cars are parked 95% of their lifetime offers a huge potential for improvement regarding car usage time and sustainable mobility. Hereby, a challenge that has to be faced is the widely spread behavior of using expensive and non-sustainable cars as a status symbol. Mankind has to get rid of this absurdity to move towards a progressive, advanced and sustainable mobility.

As already mentioned in the introduction, companies like Uber and Mobility tackle some of these challenges. However the optimum is not reached yet at all.

The mentioned companies operate with a centralized platform. Because of the centralized structure of these companies, transparency is not given at all. The pricing policy is very subjective and not always fair.

In the next Section we will show how and why using the block chain technology in the transportation industry leads to great improvements compared to the status quo.

2.2   Presentation of the Idea

In the following, the idea will be outlined. As mentioned above there are a few challenges concerning todays car sharing industry.

In this section the basic technical concept of our decentralized shared mobility platform MobChain is proposed. The system consists of three different coins that can be received differently. Only one of them has a monetary value, where the other two act like tokens, since they can only be used within the closed ecosystem of our platform. As a base the so called MobCoin (Mobility Coin) is the general means of payment. These MobCoins can be purchased using Fiat money at a bank that holds ten million in total. In return MobCoins can also be exchanged at the bank or an exchange for Fiat money. With MobCoins it is possible to pay a car owner to rent his or her car to get to a predefined destination for a specific, negotiated price.

While driving an IoT device is able to monitor the driving style of the renter. Doing so the renter is able to receive or loose so called SusTokens (Sustainability Tokens). In the beginning the wallet contains 50 SusTokens. If the renters driving style is considered non-ecological, like for example unnecessary over-aggressive braking and accelerating, she or he looses a specific amount of SusTokens. If the client tries to drive ecologically friendly or is using an electric vehicle he or she can gain more SusTokens. Owning more than 50 SusTokens stored in the wallet the renter receives a discount on the previously negotiated price of the trip using the rented car. The highest number of SusTokens to hold is defined to be 100 - which corresponds to a discount of 25%. Owning no SusTokens at all results in

a rise in the price by 25%. The discount as well as the increase in price behave linearly to the amount of SusTokens.

Furthermore, a second token is implemented beside the SusToken. The so called RepToken (Reputation Token) is a way of measuring how well the renter treated the rented car. After the user reaches the final destination with the rented car, the following renter who uses MobChains service for the next trip with the same car is obliged to examine the condition of the car. Based on the examined condition this next user will give a rating to the previous user of the car. This rating of the car is then translated into RepTokens. If the rating is positive the previous renter retroactively receives RepTokens to reward his good handling of the car, if it is negative RepTokens are taken away from his wallet. Every new user starts with 50 RepTokens and the highest number of RepTokens is bounded to 100 as in the case of the SusTokens. If the user holds more than 50 of such tokens he or she also gets a discount on the previous negotiated price for the trip. Corresponding to SusTokens the maximum discount is 25% while the maximum rise in price again is 25%, too.

Figure 2.1 gives an overview of the relations between the different types of tokens and the fiat money respectively.
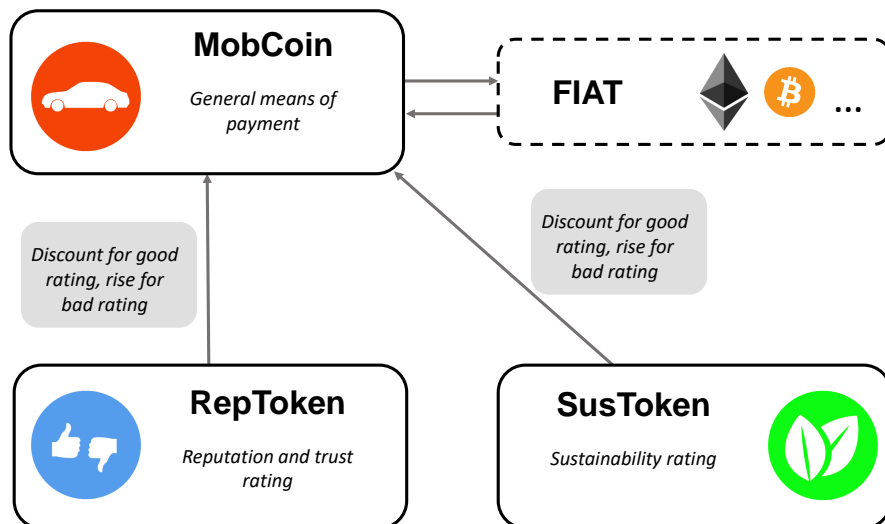

Figure 2.1: Flowchart of MobChain coin and token interactions.

With this technology renters are able to define freely to whom they are giving their car. Establishing a range of accepted levels of RepTokens and SusTokens respectively the renter is able to prohibit the renting of the car to somenbody that does not pass the predefined requierements for RepTokens and SusTokens respectively. It has to be emphasized, that only MobCoins are interchangeable in both directions. The tokens can only be earned by behaving trustworthy on the platform and acting as a sustainable road user. This key features give incentives to the users to follow the rules, since they save fiat money implicitly. On top, RepTokens and SusTokens are just valuable on the MobChain platform, which supports the longterm operability. The rating process and the evaluation of the user behavior are transparently stored on the blockchain through smart contracts and supported by real-valued discounts.

Chapter 3

Solution Design

Preliminary Remark   The design described in this section was coded within the two day long hackathon and is therefore a simplified implementation of the original concept outlined in the sections above. This means the On- and Off-Chain codes are fully functional but not all features were implemented due to the time constraint.
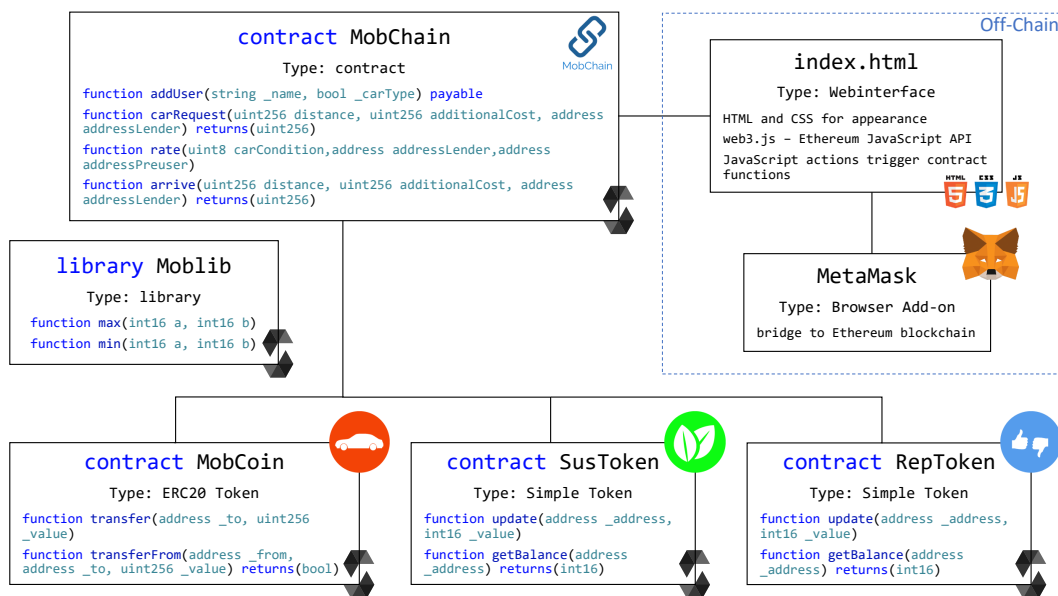

Figure 3.1: Overview graph of our solution design.

We decided to develop our application on the Ethereum blockchain, since all introductory lectures of the BIOTS class were based on this technology. There also exist various test blockchains as for example the Ropsten Testnet, which allows

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to deploy and test smart contracts on the test blockchain without the need of paying for transactions with real Ether crypto coins. To add executable code to the Ethereum blockchain or one of the testnets smart contracts written in the high level language Solidity can be used. Solidity has similarities with both C and JavaScript.

Our solution consists of one main smart contract with several subcontracts which are deployed on the blockchain and a HTML/JavaScript web interface for inter-actions with users. An overview of our solution design is shown in figure 3.1. The overview shows the dependencies and interactions between the different con-tracts and the web interface. Furthermore, the most important functions of the contracts are outlined. The different parts of the design will be discussed in more detail further down.

3.1 On-Chain

This section discusses the parts of our implementation that are deployed on the blockchain, in our case a testnet of the Ethereum blockchain.

3.1.1 MobChain Contract

The central smart contract of our solution is called MobChain (mobchain.sol). Upon its creation, the MobChain contract creates the three subcontracts Mob-Coin (mobcoin.sol), RepToken (reptoken.sol) and SusToken (sustoken.sol), where the first one is a payable ERC20 token and the later ones create the reputation and sustainability tokens, respectively. The MobChain contract includes a mapping from user addresses to the account data structure of the users of the MobChain platform. In this data structure, all the relevant user data is stored, as for ex-ample the type of car he provides for sharing (if any) and its location. The most important functions included in the contract are further explained in table 3.1.

3.1.2 MobCoin Contract

The MobCoin contract consists of a payable ERC20 token. Its main functionality is to transfer a certain amount of MobCoins from a sender to a receiver. In

Function	Description
addUser(name, carType)	Adds a new user to the database upon its registration as a MobChain user. Initializes the RepTokens and SusTokens of the new user. The inputs to the function are the name and car type of the user.
carRequest(distance, additionalCost, lenderAdress)	Upon the request of a user the car request function can provide him with the expected cost of the requested ride. The function needs as an input the distance of the ride, an additional cost term that can represent special costs for driving into certain regions, and the address of the lender of the nearest car to the user. The output are the expected costs or -1 in case the user does not have enough MobCoins to pay for the ride.
rate(carCondition, addressLender, addresPreuser)	Each user of a shared car needs to inspect the car before the ride and give a rating to the previous user. The inputs are the car condition and the addresses of the lender and the previous user. The RepTokens of the previous user are updated depending on the car condition.
arrive(distance, additonalCost, lenderAddress)	Once the user arrives at his desired destination with the rented car this function executes the payment in MobCoins from user to lender and additionally the sustainability score of the user is updated based on the fact whether the car was an electric or a gasoline car. The inputs are the same as for the car request function.

Table 3.1: Important functions included in the MobChain contract.

addition, it is invoked if a user buys MobCoins at a crypto-currency exchange[1].

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[1]For now each newly created user automatically gets 200 MobCoins transferred to its account, since the MobCoin buying feature is not implemented yet.

3.1.3   RepToken and SusToken Contract

Both the reputation token and the sustainability token have a capped minimal value and maximal value of 0 and 100, respectively. To ensure the balance stays within this bounds when the balance is updated, the update function uses the min and max functions provided by the Moblib library.

The most important functions of the subcontracts of the MobChain contract as outlined in figure 3.1 are further discussed in table 3.2.

Function	Description
transfer(to, value)	Function of the MobCoin contract (ERC20 function). This function is invoked when a user purchases MobCoins and transfers the coins to his/her account. The arguments are the wallet address of the user and the value (non-negative) in MobCoins to be transferred.
transferFrom(from, to, value)	Function of the MobCoin contract (ERC20 function). This function transfers the rent prince in MobCoins from the renter to the lender. The arguments are the two wallet addresses and the rent price (non-negative).
update(address, value)	Function of the SusToken and RepToken contracts. This function updates the user's SusToken and RepToken balance, respectively. The arguments are the user's wallet address and the balance change (positive and negative).
getBalance(address)	Function of the SusToken and RepToken contracts. This function returns the user's balance of either SusTokens or RepTokens. The sole argument is the user's wallet address.

Table 3.2: Important functions included in the token contracts.

3.2 Off-Chain

This section discusses the parts of our solution not deployed on the blockchain. This especially includes our provided web interface.

3.2.1 Web Interface

As a graphical user interface (GUI) a web-based solution was chosen. Through a website the user can interact with the main smart contract on the blockchain and create a profile or rent a car.

The web interface is programmed in HTML and uses CSS for the appearance and JavaScript for the functionality. As shown in figure 3.1, the web interface acts like an intermediary between the user and the smart contract on the blockchain. The MetaMask add-on provides the identity and wallet address of a user to the interface by injecting a web3 JavaScript object into the website. The website then utilizes the web3 API (JavaScript) to interact with the smart contract already deployed on the blockchain. In order to work, the web3 API requires the hard coded address and ABI[2] of the smart contract it should interact with. These interactions are implemented as callback functions, since code execution on the blockchain is slow in general and therefore needs asynchronous calls. If the web interface is interacting with a browser which doesn't use the MetaMask add-on, the web interface will not work at all. We utilize the wallet address as the unique identifier of a user, so without the identity provided by MetaMask there can't be an identification of a user nor can a user be created.

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[2]Application Binary Interface; This provides the function interfaces of the smart contract to the JavaScript code.

Chapter 4

Evaluation

In this section we evaluate the current state of the implementation of our proposed system.

We successfully implemented a basic version of MobChain, which includes the most crucial features. We aimed for demonstrating a basic use case of MobChain relying on a functional basic software layer. In our view we reached this goal as the following functions were implemented and properly linked:

- Interfacing the blockchain through a website where the user can create a new account and receive MobCoins.
- The user can select a start and end point for his journey and may select a car type for his rental.
- Subsequently, expected costs are calculated and shown based on the selected car type, the selected route and the current SusToken and RepToken balance of the user.
- The user can accept the rental, assuming that the ride occurs immediately. When accepted, a payment is triggered and the final amount of MobCoins is transferred from the renter's balance to the owner's balance. Additionally, the SusToken balance of the user is updated.
- In case another user rents the same car, he will evaluate the car's condition, which is compared with it's previous state and subsequently used for updating the RepToken balance of the previous user.

We implemented the MobCoin as an ERC20 token in order to be compatible with

most available wallets. Due to issues with MetaMask, we were however not able to pay Ether (ETH) in exchange for MobCoins, and therefore simply gave away 200 MobCoins to every new user for free.

The interaction with the webpage showing the functionality of the above mentioned features was recorded as a screencast and can be viewed online here.

To sum up, the basic concept of the MobChain software including the most crucial features, such as account creation, ride selection and coin transfers runs successfully on the Ropsten test network and hence demonstrates a simple use case of MobChain.

Chapter 5

Conclusion and Outlook

5.1   Conclusion

Fastly growing populations and cities confront mankind with new and difficult problems that have to be solved to ensure a sustainable and mature usage of the limited resources on earth. New emerging technologies like the blockchain technology and modern IoT devices can partially provide a solution to these tasks. Within the frame of the Blockchain and IoT School 2018 at ETH Zurich, we developed the project MobChain that faces the challenges of future mobility and urban life. In order to implemented our ideas, the Distributed Ledger and Blockchain technology were used.

We successfully set up a basic concept of the MobChain software including the most crucial features, such as account creation, ride selection, coin transfers and status updates. The different interactions between the car user, the car lender and the tokens are based on smart contracts. The implemented system runs on the Ropsten test network. On the developed webpage the user can interact with MobChain. Our implementation demonstrates a simple use case of MobChain. It allows the user to select a desired trip, a car type and calculates the expected cost. After the ride, the SusToken and MobCoin balances are updated. If the user is later rated by the next user of the car, his RepToken balance and reputation ranking is updated and will henceforth influence the costs for his future rentals. The potential user has the option to choose between an electric vehicle or a conventional car. Choosing an electric car will lead to an increase in SusTo-

kens thanks to the bigger sustainability and therefore give a bigger discount on future renting costs. This incentives created by the sustainability ranking and the implemented reputation ranking will lead to a more sophisticated, mature and sustainable driving behavior in general. Furthermore, the reputation ranking ensures a careful and gentle usage of their cars to the car lenders and controls the reliability of the car users. Hence, the created tokens additionally give an incentive to car owners to share their cars with the community without having to fear a disrespectful usage of their vehicle.

MobChain has the potential to tremendously improve our driving behavior and strongly decrease the number of vehicles on the streets. Crucial for the success of this project is the public acceptance and trust for the idea behind it. Especially in the western world we have to get rid of handling cars as status symbols, start behaving more sustainable and contributing to the well-being of the community. If these prerequisites are fulfilled and set in our minds, decentralized car-sharing systems like MobChain will provide the mobility platforms of the future.

5.2 Outlook

In the short period of time during the hackathon we were able to code the most important features of our idea. However, for the MobChain technology to be successful in the real world there are multiple highly relevant improvements that have to be added.

- Detailed analysis of the dynamics of the incentives: How do the SusToken and RepToken balances influence the user's behavior? Is the desired goal to minimize the environmental pollution met?
- Implementation of MobChain into a mobile application and a website. Without an outstanding website and mobile app it will not be possible to successfully penetrate the transportation market.
- Invention and connection of needed IoT devices to locate and evaluate the cars and their conditions. Such tools are necessary to make a decentralized platform working because there is no central entity that oversees the service. Without these features customers could shy away as they are afraid that the offered service is of insufficient quality.

Moreover, we also have some ideas on how to use the technology we created in order to expand and diversify into new markets besides the car sharing industry.

As already mentioned in the introduction our vision is it not only to offer a decentralized car sharing platform but also an Uber like application without a central entity. We are very interested in introducing the blockchain technology to the transportation service industry as it is a huge market compared to the car sharing market. During the hackathon with very limited time we had to focus on a simple implementation of our idea. That is why we implemented our idea in the car sharing industry. In the near future we want to come up with an application that is similar to Uber with the great difference that our application will run on the blockchain and therefor will be decentralized. As pointed out many times already, the decentralized system offers great improvements.

With the proposed improvements and additional ideas we think that MobChain can play an important part in making the world a better place.

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