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MobChain

The Future of Mobility

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The software code, which is part of this report is open source and available at https://github.com/ETHBiots2018/mobchain.

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Abstract

In this report, we show an application of blockchain technology in the field of shared mobility. Blockchain technology has proven to be very useful for financial transactions between individuals with no central entity involved. It nevertheless, can be applied beneficially in various other fields. In the MobChain example presented here, blockchain technology enables private car owners to share their car with other users. Thereby, the blockchain is used to execute the transactions for the shared car and at the same time builds trust between lender and renter of a car, thanks to the blockchain's transparent nature. In addition, we also introduced an incentive system to push towards a safer and more sustainable future of mobility.

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Chapter 1

Introduction

This project report was written as part of the ETH course 'Blockchain and the Internet of Things'. The course has the goal to push education for innovative new technologies at universities and to help Switzerland becoming one of the leading hubs in the blockchain and IoT space. After participating in different lectures and hands-on workshops, a hackathon was carried out where business concepts using blockchain technology were developed. In the following, we will introduce and discuss our concept.

1.1 Justification

In earlier 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, innovations such as mobile internet and smartphones were introduced. These innovations 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 cab ordering process, 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 render it unnecessary to personally own a car.

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

The two main drivers of success for 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) to revolutionize the transportation industry even more fundamentally, than Uber and Mobility did.

A lot of people think that the blockchain technology can only be used to create crypto-currencies, but this is a big misconception. 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, centralized platform providers like Uber or Mobility would be superfluous; The 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 [13]. Moreover and more importantly, we introduce a feature that motivates people to drive eco-friendly and that reduces the amount of cars needed to satisfy the demand of the entire population. We from MobChain think that this feature will mark a milestone in the process of transforming our mobility industry into a more sustainable and social one. Before getting into a detailed description of our solution in Chapter 2, Section 1.2 will give an overview on how other tech companies use blockchain technology, 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, which are dedicated to develop new possibilities to revolutionize the way we are moving from one place to another. By fundamental advances in the fields of blockchain technology, internet of things, artificial intelligence and the handling of big data, new tools for achieving this goal have emerged. In the following section, a short overview of different

startups and joint ventures aiming at this goal are 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 available capacities - in for example cars - with the transportation needs of others in real-time. By using a crypto-currency, 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 crypto-currency for their contribution to the development of the platform [10; 4].

Commuterz The peer-to-peer mobility service has the goal to enable trustless collaboration using blockchain technology extensively. The early stage startup from Israel wants to establish a carpooling service that enables non-trusting partners, like Original Equipment Manufacturers, big employers and other carpooling service providers, to synchronize their mobility needs. Using a gamification approach, tokens can be earned by the customers to incentivize the usage of Commuterz’ carpooling service [3].

Darenta Darenta is one of the most advanced companies in the field of combining blockchain technology and carsharing. The company based in Russia also has the goal to establish a car rental service for car owners who want to lend their private cars. On their platform, any person or company can rent cars including insurance using smart contracts implemented on the Ethereum blockchain. There is no commission charged to car owners and users rent a car for a price specified by the owner of the car. This concept has benefits for both: Car owners earn money when renting out their personal car, while users who want to rent a car get access to a large pool of vehicles [6; 7].

Arcade City The US-American technology startup has the goal to offer an alternative to the established ridesharing services Uber and Lyft. They offer the possibility to pay the driver directly using 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 actions growing their network [2; 9].

Tesseract The multinational professional services company Ernst & Young launched a company called Tesseract, which is dedicated to build an integrated mobility platform powered by blockchain technology. Similar to the other projects mentioned above, a platform has been established which offers fractional vehicle ownership, shared use and seamless multimodal transport. The future goal is to lay the foundation for how autonomous vehicle fleets can be owned in the future and provide access to a variety of on-demand mobility options [8].

Others Increasingly, different companies are trying to push blockchain technology in different parts of our daily mobility. For example ZF, UBS Bank and Innogy - part of RWE's innovation hub - have the goal to establish automated transactions for gas or electric power managed by the car itself. Cooperating with the startup Slock.it an e-wallet for cars is implemented [5].
The swiss insurance company AXA partners with AdNovum, the University 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 technology. This information concerning the state of a car, can be used by the manufacturers, the insurance companies and other involved partners [1].
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 [11].

The overarching objectives in the examples above are: Creating transparency and building trust among users by reducing the risk of fraud and reducing or eliminating transaction costs using blockchain technology [12].

Chapter 2

Challenge and solution

2.1 Current challenges faced by the mobility sector

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. Reducing the amount of cars in cities also leads to a reduction of parking spaces, which thereafter can be used as recreational, working or living spaces. Furthermore, as the reduction of carbon dioxide emissions is one of the major challenges in today's world, it is absolutely necessary to reduce the amount of cars driving in cities and 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 is/are only one or two passenger/s per car. This directly leads to an increased waste of fuel and to congested roads, too. 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, one of the challenges 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 form of mobility.

As already mentioned in the introduction, companies like Uber and Mobility tackle some of these challenges. However, the optimum is not reached yet and there is still room for improvement. The mentioned companies operate with a centralized platform. Due to their centralized structure, transparency is not always given. The pricing policy is very subjective and not always fair.

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

2.2 Presentation of the Idea

In the following, our concept will be outlined. As mentioned above, there are a few challenges concerning today's car sharing industry, for some of which we will propose solutions here.

In this section, the basic technical concept of our decentralized shared mobility platform MobChain is proposed. The system consists of three different tokens which can be received in different ways. Only one of them has a monetary value, whereas the other two purely act as tokens, since they can only be used within the closed ecosystem of our platform. As a base token, the so called MobCoin (Mobility Coin) is the general means of payment. These MobCoins can be purchased or exchanged using Fiat money at a bank or crypto-currency exchange. 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, calculated price.

While driving, an IoT device is monitoring 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 renter's driving style is considered non-ecological - like for example unnecessary over-aggressive braking and accelerating - he or she looses a specific amount of SusTokens. If the renter tries to drive eco-friendly or is using an electric vehicle he or she gets

rewarded with SusTokens. Having more than 50 SusTokens stored in the wallet, the renter receives a discount on the previously calculated price of the trip using the rented car. The maximum number of SusTokens per user is defined to be 100 - which corresponds to a discount of 10%. Owning no SusTokens at all, results in a penalty on the price by 10%. The discount, as well as the increase in price behave linearly to the amount of SusTokens.

Furthermore, a second token is introduced additionally to 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 successive renter who uses MobChain's 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 rate the previous user of the car. Right now this is the only behavioral rating implemented, however there are several different mechanisms which could be implemented to rate users. This rating of the car is then translated into RepTokens. If the rating is positive, the previous renter retroactively receives RepTokens to reward his/her good handling of the car, if it is negative, RepTokens are deducted from his/her wallet. Every new user starts with 50 RepTokens and the maximum number of RepTokens is capped at 100 as in the case of the SusTokens. If the user holds more than 50 of such tokens, he or she also receives a discount on the previously calculated price for the trip. Corresponding to SusTokens the maximum discount is 10%, while the maximum penalty is again 10%.

Figure 2.1 gives an overview of the relations between the different types of tokens and the Fiat money, respectively.
With this mechanism renters are able to define freely to whom they are lending their car. Defining 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. It has to be emphasized, that only MobCoins are interchangeable in both directions. The two tokens can only be earned by behaving trustworthy on the platform and/or acting as a sustainable driver. This key features give incentives for the users to follow the rules, since they save money at the end of the day. In addition, RepTokens and Sus-

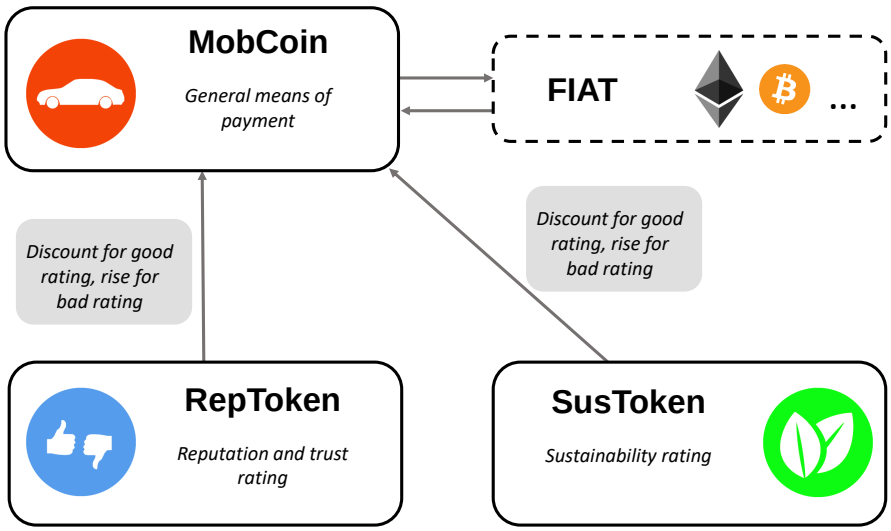

Figure 2.1: Flowchart of MobChain coin and token interactions.

Tokens only have an inherent value on the MobChain platform, which supports the longterm operability. The rating process and the evaluation process of the user 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 chapter was implemented 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.

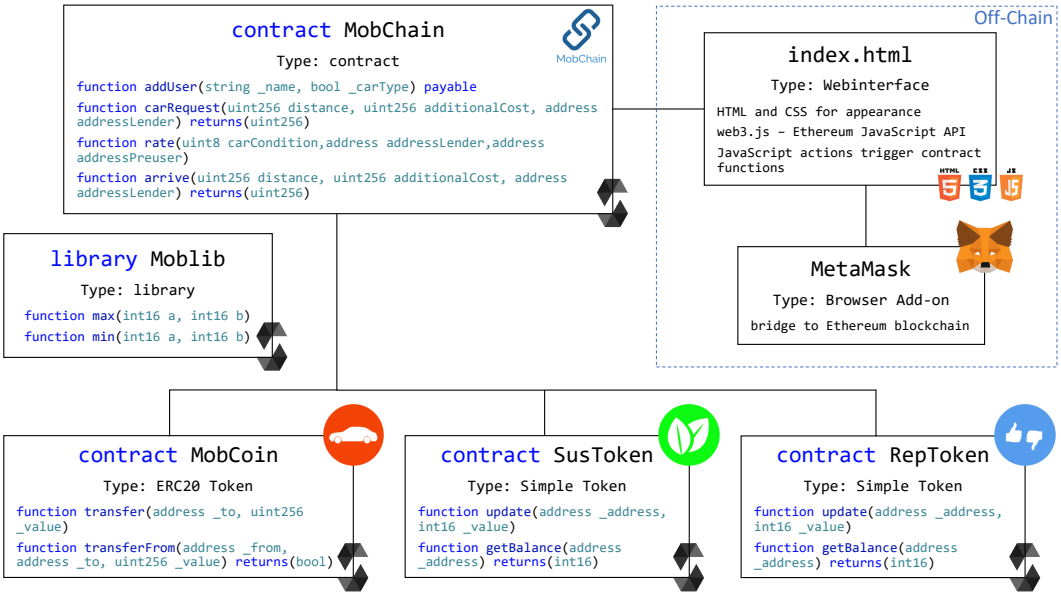

Figure 3.1: Overview of our solution design.

We decided to develop our application on the Ethereum blockchain, since all introductory lectures of the BIOTS class were based on this technology. In addition, there exist various test networks - as for example the Ropsten test net -

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

Our solution consists of a main contract with several subcontracts, which are deployed on the blockchain and a HTML/JavaScript web interface for interactions with the user. An overview of our solution design is shown in figure 3.1. The graph shows the dependencies and interfaces between the different contracts and the web interface. Furthermore, the most important functions of the contracts are outlined. The different parts of the design will be discussed in further detail below.

3.1 On-Chain

This section discusses the parts of our implementation which are deployed on the blockchain itself, in our case a test network of the Ethereum blockchain.

3.1.1 MobChain Contract

The main smart contract of our solution is called MobChain (mobchain.sol). Upon its creation, the MobChain contract creates the three subcontracts MobCoin (mobcoin.sol), RepToken (reptoken.sol) and SusToken (sustoken.sol), where the first one is a payable ERC20 token and the latter ones define the reputation and sustainability tokens, respectively. The MobChain contract includes a mapping of user addresses to the user account data structure of the MobChain platform. In this data structure, all the relevant user data is stored, as for example the type of car the user provides for sharing (if any) and its location. The most important functions defined in the contract are individually discussed in table 3.1.

Function	**Description**
addUser(name, carType)	Adds a new user to the database upon his/her 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/her with the expected cost of the requested ride. As an input the function needs 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 car closest to the user. The output is the expected costs or -1, in case the user does not have enough MobCoins to pay for the ride.
rate(carCondition, addressLender, addresPreuser)	Each renter needs to inspect the rented 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 RepToken balance of the previous user is then updated depending on the car condition.
arrive(distance, additonalCost, lenderAddress)	Once the user arrives at his/her desired destination with the rented car this function executes the payment in MobCoins from user to lender and additionally updates 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.

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

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. Since the Solidity language is still in development, there are no libraries providing basic math functions. Hence, we had to implement our own 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.

3.2 Off-Chain

In this section, the parts of our solution not deployed on the blockchain are discussed.

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 as 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

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

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.

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

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

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. Hence, there will be no functionality available to the user.

Chapter 4

Evaluation

In this chapter we evaluate the current state of the implementation of our proposed solution.

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

- Interfacing the blockchain through a website, through which 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/her 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 the ride occurs immediately. Upon arrival, the payment is automatically triggered and the final amount of MobCoins is transferred from the renter's account to the account of the owner. Additionally, the SusToken balance of the user is updated.
- In case another user rents the same car, he/she will evaluate the car's condition, which is compared with its previous state and subsequently used to update the RepToken balance of the previous user.

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

with most available crypto wallets. Due to issues with MetaMask, we were not able to implement a MobCoin buying feature, with which Ether coins (ETH) can be exchanged to MobCoins. Therefore, we simply give away 250 MobCoins to every new user for free. As a demonstration, a dummy interaction with the web interface, showing the functionality of the above mentioned features was recorded as a screencast and can be viewed online, on https://n.ethz.ch/ jsieber/.

Summarizing, 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 the MobChain platform.

Chapter 5

Conclusion and Outlook

5.1 Conclusion

Fast growing populations and cities confront mankind with new and difficult problems, which 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 challenges. Within the frame of the Blockchain and IoT School 2018 at ETH Zurich, we developed the MobChain platform which addresses the challenges of future mobility and urban life. In order to implement 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 and the car lender plus the token transfers are based on smart contracts. The implemented system runs on the Ropsten test network. Through the developed web interface the user can interact with the MobChain platform. 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 gets a rating on how he/she handled the car, the user's RepToken balance - representing his reputation ranking - is updated accordingly. Henceforth, this balance will influence the costs for his/her future rentals. In general the user has the option to choose between an electric vehicle or

a conventional car. Choosing an electric car will lead to an increase in SusTokens thanks to its higher sustainability and therefore give a higher discount on future rentals. This incentives created by the sustainability and reputation ranking, will lead to a more sophisticated, mature and sustainable driving behavior in general. Furthermore, the reputation ranking ensures a careful and gentle handling of the rented cars 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 behavior regarding transportation and strongly decrease the number of vehicles on the streets. Crucial for the success of this project is the public acceptance and trust in the idea behind it. Especially in the western world we have to get rid of treating cars as status symbols and 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 time during the hackathon we were able to implement the most important features of our idea. However, for the MobChain platform to be successful in the real world, there are multiple highly relevant improvements which have to be realized:

- Detailed analysis of the incentives' dynamics: How do the SusToken and RepToken balances influence the user's behavior? Is the desired goal to minimize the environmental pollution met?
- Development of a mobile application and a more sophisticated website. Without an outstanding website and mobile application, it will be impossible 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.

In addition, we have some ideas on how to use this concept to expand and diversify into new markets other than the car sharing industry.

As already mentioned in the introduction, our vision is not only offering 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, since it is as huge a market as the car sharing market. With very limited time on our hands, 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 therefore 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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