Demo Abstract: A Blockchain-based Payment and Validity Check System for Vehicle Services

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Abstract

Self-driving cars rely on several services to operate, some of which require financial interactions, such as paying for parking spaces or paying for battery charging in the case of the electric vehicles. Providing these services demands the cooperation of several parties and organizations that do not necessarily trust each other. Over the past few years, several blockchain-based services have been introduced to enable users with a safe and secure medium for conducting business in a trustless environment. In this work, we propose a blockchain-based solution to enable vehicles to consume and pay for services.

Keywords Blockchain, Ethereum, eWallet, Automated Payment

1 Introduction

Drivers of conventional vehicles have to conduct many manual tasks such as charging, fueling, or parking. Most of these tasks require payment actions that are implemented in different manners (i.e., subscription model, cash or credit card payment, and contract-based payment). With the adaptation of fully autonomous cars (level 4 or 5 [4]), it is necessary to process these payments automatically, since there will not be a driver to conclude the tasks.

To prepare for the future of autonomous cars and also to make the life of an everyday car owner easier, we propose an integrated electronic car wallet (eWallet), which enables the vehicle to generate value and act as an individual business unit. The eWallet connects to several ecosystems that handle the processing and communication with different service providers. The eWallet and ecosystem combination can be used to automatically pay all fees and costs the vehicle generates as well as handle the authentication process when communicating with infrastructure such as barriers at a parking lot [5]. It enables micro or nano payments for higher accuracy when billing the charging or parking events. Furthermore, the eWallet also potentially allows generating income through the car or ride-sharing functionalities. Additionally, by benefiting from a blockchain-based environment, the proposed solution provides a safe and secure approach where the users are not required to trust a single organization. Also, the system offers high transparency through tracking the vehicles consumed resources on the blockchain and reduces the need for a payment service provider and, thus, the operational costs.

2 Related Work

Several providers offer their services digitally. Companies like Ryd[1] or Pace[2] cooperate with different providers to offer limited services for smartphone-based payment solutions for fueling or charging. However, there have been limited blockchain-based solutions. In Hanada et al. [3], the authors describe a machine-to-machine communication system using smart contracts. In Baza et al. [1], the authors propose a central charging coordinator using blockchain technology. They implement a smart contract for maximizing the delivered electrical power to the vehicles based on the grid capacity and its limitations. Both works focus on smart contract implementation and do not provide a service for the vehicle side. The authors in [2] describe a blockchain-based framework to track vehicle bus data on the blockchain. Their solution connects vehicles, maintenance service providers, vehicle manufacturers, law enforcement, and insurance companies, but does not provide a payment solution.

3 Technical Approach

The main objective of the integrated wallet is providing a native ecosystem for enabling the car to connect to and consume services and to pay for the consumptions. To demonstrate the applicability of the solution, we first focus on an

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[1] https://ryd.one/
[2] https://www.pace.car

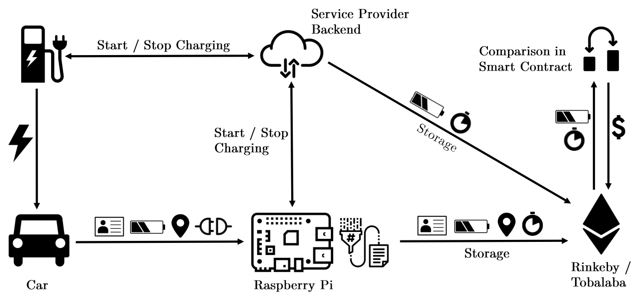

Figure 1. The workflow of a charging event.

electric vehicle charging use case, as Figure 1 displays. We use a Raspberry Pi to emulate the Vehicle Engine Control Unit (ECU). The Raspberry Pi connects to the diagnosis interface (OBD2) of the car, which allows us to work with the real vehicle bus data and to collect the requirements when replacing the Raspberry Pi with the actual in-car ECU since it has similar resource constraints.

As soon as the charging cable is plugged in, we read the event from the vehicle bus. Then, we trigger the *start charging* event at the charge point. To record the start of the charging process in a safe and trusted manner, we store a hash of the vehicle information, including the vehicle identification, timestamp, and state of charge of the battery on the Ethereum blockchain, through a transaction which is signed by the embedded device. To increase the users' privacy, we store the user data off-chain. Once the charging cable is unplugged, the charging process is terminated through the *stop charging* event. Consequently, we store the hash of the updated vehicle data on the Ethereum blockchain.

To ensure secure payment of the charging process that can be trusted by all involved parties, we use an Ethereum smart contract. This contract allows comparing the data of the charge point with the data of the vehicle. Depending on the business model of the charge point operator, we either compare the charging duration or the charging consumption. If the respective values lie within a certain threshold, we trigger the payment automatically. Depending on the provider, the payment can be made using blockchain technology (e.g., through a stable coin to prevent the price fluctuation of the cryptocurrencies), or using conventional means like a credit card.

4 Evaluation

To evaluate the design, we compare the latency that the user experiences when using our designed automated system with an existing manual and not-automated platform which authenticates users using an NFC card at the charge point and accepts payment using the beforehand provided payment information. We also compare the cost of running the platform, especially regarding the transaction fees for Ethereum. Our evaluation shows that our solution based on the Ethereum test-net blockchain is, on average, 30% faster than the existing manually-operated platform. Our solution can reduce the cost of using the system by almost 50% at an Ether price of 300$.

Among different smart contract designs, we also observed that the most efficient solution combines the systems' logic into one smart contract, which stores a hash of the vehicle data on the blockchain and automatically compares the consumed energy. Also, using only one smart contract for storing and comparing the data, instead of using several contracts, saves Ethereum Gas costs when deploying the smart contract. It also decreases the latency of the execution since we can store the data and compare it using only one transaction. However, the one-contract approach violates the principle of the separation of concerns.

Finally, our solution cuts the number of involved parties to half since many intermediaries (i.e., Charge Point Aggregators or Payment Providers) are not required in this system.

5 Conclusion

In this work, we presented an integrated car wallet that enables the vehicle to pay for services automatically. The solution provides reliable storage for vehicle data, an automated plausibility check of the consumed energy through smart contracts, and payment using the blockchain technology. Our approach could provide a solution for autonomous cars, which are required to pay for services without user interactions. In future work, we will extend our system to support payment for other services, and also we will study the impact of using the Ethereum main-net.

References

[1] M. Baza, M. Nabil, M. Ismail, M. Mahmoud, E. Serpedin, and M. Rahman. 2018. Blockchain-based Privacy-Preserving Charging Coordination Mechanism for Energy Storage Units. *arXiv preprint arXiv:1811.02001* (2018).

[2] M. Cebe, E. Erdin, K. Akkaya, H. Aksu, and S. Uluagac. 2018. Block4Forensic: An Integrated Lightweight Blockchain Framework for Forensics Applications of Connected Vehicles. *IEEE Communications Magazine* 56, 10 (2018), 50–57.

[3] Y. Hanada, L. Hsiao, and P. Levis. 2018. Smart Contracts for Machine-to-Machine Communication: Possibilities and Limitations. In *2018 IEEE International Conference on Internet of Things and Intelligence System (IOTAIS)*. 130–136.

[4] SAE International. 2018. Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles (J3016). https://www.sae.org/standards/content/j3016_201806/ Accessed:2018-10-27.

[5] ZF. 2017. Car eWallet: In Zukunft zahlt dein Auto selbst. https://www.mobilegeeks.de/artikel/car-ewallet/ Accessed:2018-10-27.