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FRACTIONAL VEHICLE OWNERSHIP AND REVENUE GENERATION THROUGH BLOCKCHAIN ASSET TOKENIZATION

Elena Vitelaru¹, Luca Persia²

Sapienza University of Rome
Transport and Logistics Research Centre (CTL), Rome, Italy
¹elena.vitelaru@outlook.it, ²luca.persia@uniroma1.it

The automotive industry is on a continuous transition towards a more sustainable and integrated ecosystem influenced by the fast-paced adoption of Electrical Vehicles (EVs) and the developments of emerging technologies such as Automated Vehicles (AVs). The road transportation sector is also experimenting with the emergent decentralized blockchain technology in various ways ranging from supply chain transparency to insurance and tokenization. Some of the recent use cases are the use of Non-Fungible Tokens (NFTs), unique digital assets designed to be immutable, to certify ownership of a vehicle, the data history of it or just for fan base development. The current paper reviews the literature findings concerning the potential of Non-Fungible Tokens for the automotive industry and proposes a new car ownership and revenue generation model using the ERC-1155 token standard. Our proof-of-concept based on fractional vehicle ownership demonstrates the feasibility of such a model that allows for revenue distribution amongst the vehicle owners according to the percentile invested in the vehicle acquisition.

Keywords: Fractional vehicle ownership, blockchain, non-fungible tokens

1. Introduction

We are witnessing a period of profound transformations in the automotive industry that is adapting to new environmental and societal requirements with technological progress being the highest external force that is being seen as a catalyst of change (IBM, 2018). The industry 4.0 paradigm harnesses the power of sensors and big data and the development of emerging decentralized technologies such as blockchain that could revolutionize the way in which we design, own, and operate vehicles in the future. The characteristics of blockchain such as immutability, scalability, integrity, resilience, and transparency make it ideal for the Internet of Things (IoT) world where vehicles are powered by renewable energy, autonomous and connected with each other and the environment around them (Viriyasitavata and Hoonsopon, 2019). The evolution towards new mobility models such as Car as a Service or Mobility as a Service is also positively influenced by the possibilities offered by decentralized technologies, with use cases in the automotive industry ranging from manufacturing, supply chain transparency to insurance, tokenization etc. Among the blockchain use cases within the automotive industry, non-fungible tokens (NFTs) represent one of the most interesting solutions that allow for fractional ownership using the recently developed ERC-1155 token standard. This token standard allows the non-fungible tokens to be fractionalized into ERC20 tokens and opens new possibilities for the automotive industry.

The present paper reviews the literature findings regarding the use of Non-Fungible Tokens in the automotive industry and attempts to present an example of a peer-to-peer car sharing revenue generation model using the ERC-1155 token standard for fractional vehicle ownership, allowing thus for revenue distribution amongst the vehicle owners according to the percentile invested in vehicle acquisition, could work. The paper is structured in five parts. The second section explains the concepts of decentralized technology, NFTs and tokenization and section three presents several non-fungible token use cases in the automotive industry developed so far. Section four explains the proposed revenue generation model using the 1155 token standard and the possibilities that arise with fractionalization for the peer-to-peer mobility and the fifth section is dedicated to overall conclusions.

2. What is blockchain and how does tokenization work?

Ever since Satoshi Nakamoto published the paper “Bitcoin: A Peer-to-Peer Electronic Cash System” in 2008 where he presents a revolutionary peer-to-peer version of electronic cash that allows for online payments to be executed between parties without the intervention of an intermediary, there have been a multitude of developments and definitions on what decentralized ledger technologies represent (Nakamoto,

2008). The basic interpretation is that distributed ledgers are databases that are held and updated by each node/participant in the network, lacking thus the central authority and requiring consensus for the update of the network with each node having a copy of the ledger (Buterin, 2017).

The Ethereum founder Vitalik Buterin sustains there are three levels or “axes” of decentralization:

1. “Architectural (de)centralization - how many physical computers is a system made up of? How many of those computers can it tolerate breaking down at any single time?
2. Political (de)centralization - how many individuals or organizations ultimately control the computers that the system is made up of?
3. Logical (de)centralization - does the interface and data structures that the system presents and maintains, look more like a single monolithic object, or an amorphous swarm? One simple heuristic is: if you cut the system into half, including both providers and users, will both halves continue to fully operate as independent units?” (Buterin, 2017).

Decentralization is essential for blockchain, guaranteeing its optimal functioning outside of any central authority control. As per the most common definition, blockchain is a distributed immutable ledger that allows peer-to-peer transactions and keeps records of it over all the nodes of the network for tangible or intangible assets (IMB, 2020). The key elements of blockchain are the distributed ledger technology that removes the need for trust in any central authority, immutable records since no transaction can be deleted from the blocks and smart contracts that are stored on blockchain and are executed automatically. The way in which blockchain works is that each transaction is recorded into a block and every block is connected to the prior one and the blocks that come after, so no transaction can be changed or deleted. The difference between decentralized ledger technology and blockchain is that blockchain is just one type of distributed ledger, although the terms are easily interchanged.

Blockchain technology has proved that it has the potential to revolutionize traditional business models starting with the finance industry to manufacturing, insurance companies, real estate, automotive and many more industries. Tokenization of assets, non-fungible tokens, fractionalization, all have high potential to change the way we own and invest in assets and the present paper focuses precisely on how tokenization and fractionalized NFTs could generate revenues when used within a peer-to-peer Car Sharing business model.

3.1. What is tokenization?

Tokenization is the process through which digital tokens that represent either digital or physical assets (Hedera, 2022) are created on blockchain. Once the tokens are bought, the ownership of the asset is immutable, meaning that the proof of ownership cannot be changed or erased.

There are two types of tokens: fungible and non-fungible. As for the main characteristics, the fungible tokens are interchangeable and divisible, meaning they can be exchanged for the same value (1 bitcoin for 1 bitcoin) and that they can be divided into decimal pieces. The non-fungible tokens, on the other hand, are unique and cannot be interchanged or divisible. Tokenization can be used with almost any use case but mostly they are grouped in categories such as asset tokenization, equity, funds, and services. When creating the tokens, either fungible or not, the token standard must be specified.

A token standard stands for Ethereum Request for Comments (ERC) that are application-level specifications, basically a set of rules that allow anyone to create tokens on different blockchain protocols (Crypto.com, 2022). When creating ERC tokens there must be explicitly stated the standard so that the smart contract can seamlessly execute all the functions required. The most popular ERC token standards are:

- ERC-20;
- ERC-721;
- ERC-1155.

The ERC-20 is the most known and used standard due to its fungibility, meaning that it can be exchanged just like a normal currency would. It is the most common token standard used to create and issue smart contracts on the Ethereum blockchain.

The ERC-721 token standard is at the core of creating non-fungible tokens ranging from unique collections of art or to ownership of private land, avatars or exclusive club membership, gaming and many more. Apart from being unique and non-fungible, the ERC-721 allows for the transfer of NFTs between different accounts so the NFT can be traded for other currencies, it permits the query for finding out the owners of specific assets and it can also identify the total supply of NFT sets that exist on the blockchain network.

The ERC-1155 token standard was introduced in 2019 by the team working on the Enjin project and it solved the issue of the batch transfers that with the ERC-721 had to be done individually and had high costs. Using the new standard, multiple assets can be transferred on a single smart contract avoiding the high gas costs. One of the most important features of the ERC-1155 token is that it allows for both fungible and non-fungible tokens and semi-fungible tokens to be included on the same smart contract and address, opening new possibilities for NFT fractionalization.

4. Non-fungible token (NFTs) use cases in the automotive industry

The emergent blockchain technology has been used so far by large players in the automotive industry such as BMW, Lamborghini, Renault, Hyundai and many more due to its decentralized nature which has potential to change the modus operandi due to its increased transparency and immutability of data. To this purpose, leading car manufacturers joined forces and launched the Mobility Open Blockchain Initiative (MOBI) to advance the use of the technology in the industry, ranging from supply chain management use cases, digital passports for vehicles, insurance, secure payments and many more.

The potential of Ethereum smart contracts has been explored beyond the common ERC-20 token standard, allowing thus for the skyrocketing development of the non-fungible tokens using the ERC-721 standard token. The most common understanding of non-fungible tokens is that they represent a one-of-a-kind token due to their exclusive proof of ownership. They cannot be replicated and or falsified due to their uniqueness, hence the non-fungibility. NFTs experienced a powerful surge in popularity starting in 2021, with several million dollars' worth of collections (CryptoPunks and Bored Ape Yacht Club etc.). The non-fungible token market (NFT) has seen incredible growth in 2021 with total NFT trading volume reaching \$8.8 billion and is forecasted to reach US\$ 7.63 billion by 2028, from US\$ 1.59 billion in 2021, at a CAGR of 22.05% during 2022-2028 (The Block Research, 2022; QY Research Group, 2022).

It is not surprising therefore that NFTs have caught the attention of big players from the automotive industry such as Lamborghini, Nissan, Ferrari, Alfa Romeo, Porsche, Mercedes-Benz, Rolls-Royce, Audi, etc. that are experimenting with different ways to integrate NFTs into their products. The increasing popularity of NFTs that initiated in 2021 when over \$44.2 billion worth of cryptocurrency were sent to ERC-721 and ERC-1155 contracts has been therefore a major factor in getting global brands involved (Chainalysis, 2022). This has led to the creation of unique digital assets being used in the automotive industry for projects such as:

- Brand campaigns:
 - Lamborghini, the Italian luxury automobile company, has released their first NFT in January 2022, in collaboration with the artist Fabian Oefner. The NFT collection entitled “Space Time Memory” is made up of five pairs of linked digital and physical art. The Fig.1 shows the NFT where a Lamborghini car is depicted breaking into thousands of pieces as it races towards outer space like a rocket ship. The winning bidders of the non-fungible token project received a physical “Space Key” made of carbon fibres, with an engraved QR code linking to the digital artwork, sent by Lamborghini to the International Space Station as a part of a research project from 2019. (Lamborghini, 2022).
 - Chevrolet has debuted into the NFT world in June 2022 with an auction where the winning bidder will have “the opportunity to not only get one in Minted Green, but to Own the Color - Chevrolet is offering drivers an opportunity to bid on a 1-of-1 piece of NFT artwork created by xsullo, along with a first—and only—of its kind 2023 Corvette Z06 in Minted Green.” (Chevrolet, 2022) Unfortunately, the auction held on SuperRare was closed twice with zero bids and left open the question of how a high price ceiling is impacting the success of similar NFT projects.

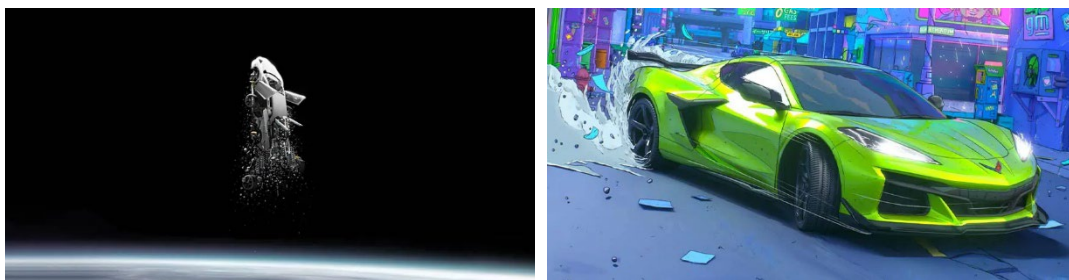


Figure 1. “Space Time Memory” NFT Lamborghini (left) and “Own The Color” NFT by Chevrolet (right)

- Fan based campaigns: Ferrari and the Velas Network have started collaborating in 2021 on a collection of NFTs that were supposed to provide the brand fans with access to exclusive digital content (Ferrari, 2022). The partnership worth \$30 million a year was aimed at increasing fan engagement through nonfungible tokens (NFTs) and other shared ideas, but it was ended towards the end of 2022 due to claims that Ferrari was being noncompliant with the clauses that allowed Velas to create NFTs. (RacingNews365).

- **Proof of ownership:** Nissan Canada and its partnership with futurist Alex McLeod has led to the creation of GT-R NFT artwork in 2021, set for auction and that came with a free real Nissan GT-R NISMO Special Edition. The results were that the Nissan GT-R digital artwork has sold for CAD\$2,850,660, or more than ten-times over the original reserve of CAD\$280,000, making the project a success.



Figure 2. Nissan Canada GT-R NFT by Alex McLeod

- **Vehicle data:** In 2022, Alfa Romeo announced that its new SUV model Alfa Romeo Tonale will have a digital NFT certificate that will record vehicle data. As specified by the automotive company “with the customer’s consent, the NFT will record vehicle data, generating a certificate that can be used to assure the car has been properly maintained”. The certification’s objective was to enhance the “credibility for owners or dealers to count on” but the technical details concerning the blockchain network or the data to be stored in the NFTs are yet to be revealed.

Although the non-fungible tokens are a new field, there is limitless potential to what could be transformed into an NFT and how the automotive industry could take advantage of this technology. Unique fan experiences, auctions and live events NFTs, to original sketches and exclusive club membership, to metaverse, there are many advantages and opportunities that tokenization can bring into the automotive industry. This paper presents a different use case for fractional NFTs that could improve the peer-to-peer Car Sharing business model. The next section details further how such a project could work.

5. Fractional vehicle ownership and peer-to-peer revenue generation model

With NFTs that represent unique digital assets on the blockchain, the standard used for their creation is ERC-721 that allows for the creation of unique custom tokens that cannot be replicated or interchanged. As mentioned, the developments in the blockchain space have led to the creation of another token standard, the ERC-1155, that has different properties and solves the issue of non-fungibility posed by the ERC-721 token standard. The decision to use the newer ERC-1155 multi-token standard in this proposed vehicle ownership tokenization and revenue generating model was made due to the specific properties of this token standard that permit the creation in just one smart contract of different types of tokens: fungible, non-fungible, and semi-fungible. Also, with ERC-1155, the smart contract does not need to store additional metadata that could be limiting efficiency and flexibility.

This section begins with explaining the concept of non-fungible token fractionalization and continues by showing how the process of a peer-to-peer fractional vehicle ownership model could work.

A fractional NFT is an NFT that was split into smaller fractions and gives the possibility to more people to claim ownership of the original piece. Fractionalization is being done through the smart contract that generates ERC-20 tokens that are connected with the original non-fungible token, giving thus a percentage to each one of the owners. There are many NFTs, especially in the art and collectibles category, that are being fractionalized and traded/exchanged on secondary markets. Fractionalization offers the possibility to hold shares of tokens in projects that are above one’s liquidity availability, so it is being regarded as breaking down the entry barriers for certain categories of investors. The concept of fractionalization is being utilized in various industries ranging from physical assets to real estate, fashion, metaverse land, luxury assets and more (Fractional, 2021).

The concept proposed in the current paper is that the vehicle itself is being created and minted as a non-fungible token, using the 1155 token standard which gives us the possibility of having the initial NFT fractionalized into ERC-20 tokens. Therefore, in the same smart contract the vehicle is minted as NFT worth 100 tokens, and those shares are bought by three addresses according to the following percentages:

owner 1 buys 25%, owner 2 buys 25% and owner 3 pays 50% of shares.

Given that now the ownership of the car belongs to three addresses, and the vehicle is supposed to be used for car sharing, a transaction representing a ride is being executed and the revenue from it is being automatically distributed by the smart contract to the owners of the vehicle according to the ownership percentages mentioned above. Fig.3 illustrates the process flow:

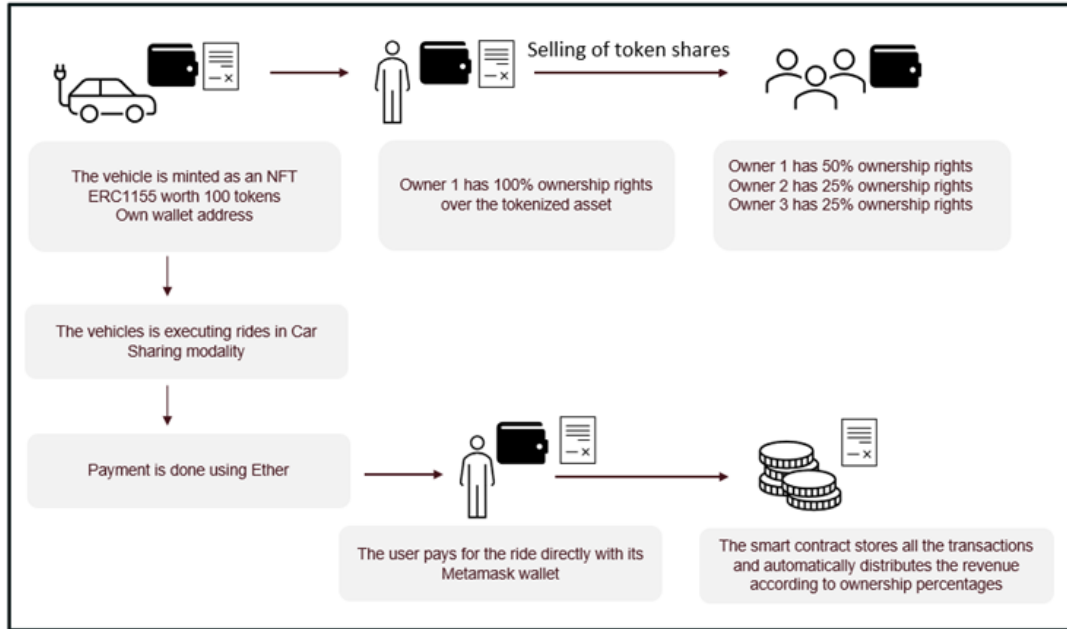


Figure 3. Process Flow

The interest for the proof of concept developed has been tested through quantitative research with data collected through a survey in the year 2021 focused on fractional ownership of an autonomous vehicle executing predefined rides. The survey had 188 respondents from over 20 countries, with 67.6% below 34 years old, 25.5% from 35 to 50 years old and 6.9% over 50 years old. The survey results showed that 61% of the participants were interested in owning a fraction of an autonomous vehicle if it could generate revenue from rides.

The steps taken to simulate the fractional ownership of a vehicle and the automatic distribution of revenue are detailed in the figures below starting with creation of the non-fungible token representing the vehicle, having 100 shares that are created automatically and deciding the amount to pay per share. Once the 100 shares of the non-fungible token are available, they are bought by three addresses according to the following percentages: owner 1 bought 25%, owner 2 bought 25% and owner 3 bought 50%. The last step is to simulate a ride where the revenue obtained is sent directly by the smart contract of the vehicle to the wallet addresses of the three owners according to the ownership percentage that each one has.

mint

metadataURI:

amount_per_share:

transact

buyShares

nftId:

amount:

transact

1. Mint the car as a non-fungible token: 100 shares that are created automatically.

2. The 100 shares of the non-fungible token are available to be bought.

Figure 4. NFT minting and available shares

3. The shares are bought by three addresses according to the following percentages: owner 1 bought 25%, owner 2 bought 25% and owner 3 bought 50%.

Figure 5. Distribution of available shares

4. When the user books a ride, the payment goes to the wallet address of the vehicle and the smart contract automatically distributes the revenue according to the ownership percentages.

Figure 6. Ride revenue distribution

To understand how such a product could look like a Proof of Concept front-end interface was also developed, currently functional on the Goerli testnet from Ethereum.

Figure 7. PoC Car details

The decentralized application also allows users to buy fractions of the vehicles available for sale. This new ownership model could open investment possibilities for a new category of stakeholders that cannot or do not wish to own an entire car and could acquire just fractions of one or several vehicles. Those fractions could later generate revenue due to the use of vehicle for rides around the city or on predefined routes.

Conclusion

The Ethereum ecosystems with its smart contracts have proved to have enormous potential for many industries, including the automotive one where traditional vehicle ownership models are forecasted to change in the future. In this paper, we proposed a proof of concept for a decentralized application that allows users to transform their vehicle into a non-fungible token, to fractionalize it and sell or buy the shares, as well as simulating a ride that automatically distributed the revenue based on vehicle ownership percentages. Fostering decentralization, transparency and inclusion through the possibilities given by fractional ownership to different types of stakeholders, the advantages of the innovative proof-of-concept presented are enhanced by the fact that it can be applied to various scenarios ranging from:

- private or business owned vehicles;
- autonomous vehicles on predefined routes;
- car sharing of different fleet sizes;
- personal or various sizes of taxi fleets.

The limitations of the model presented regard the development exclusively on the test network and the choice of using a single cryptocurrency for the simulation. The next steps are focused on functionalities such as unlocking the vehicle, microtransactions and the current legal framework that were not detailed in the present paper.

The field of blockchain and asset tokenization is new and future research is needed to uncover the potentialities of this technology for the transport industry. Among the areas where future research can focus on, we can mention the need for clarifications regarding the regulatory framework for tokenized assets, assessing the potential of distributed technology for urban mobility in the context of smart cities and studying the impact of fractional vehicle ownership on shared mobility models that are redefining our relationship with the vehicles.

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