# VMC.AI

# A new Blockchain Platform Designed for the Future of Human Mobility

Jochem Verheul, Max Mijnheer, Joey Ferwerda

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**Abstract**

The technological fundamentals of how we travel are changing rapidly. Large corporations are at the forefront of these developments. Driven by the goal of becoming the dominant solution, these corporations are building centralized ecosystems. Despite all their remarkable achievements, our global transportation infrastructure still contains many inefficiencies. Concepts like Mobility as a Service (MaaS) and peer to peer (p2p) car/ride sharing are still in an early phase. Meanwhile, our use of roads, vehicles and resources is extremely inefficient. Traffic jams, poorly connected regions, pollution and a far from perfect road safety are the natural consequences.

This paper introduces VMC CORE, a new blockchain platform. Designed for the future of human mobility, VMC CORE is open source, secure and decentralized by design. We use a consensus algorithm called Proof of Elapsed Time (PoET) to effectively achieve overall system reliability. VMC CORE is fuelled by a stable-coin called the `VAI` token, which incentives participants to develop an autonomous mobility economy that belongs to the community. On the foundations of VMC CORE we are building VMC GO, an open marketplace platform where developers can build DApps to offer mobility services. People and companies can generate `VAI` by connecting their vehicle to the network. Additionally, VMC provides a vehicle communication standard (VMC DRIVE) and framework that splits data and optimizes data validation. It drastically reduces bandwidth and increases the effectiveness of the data generated and required by autonomous vehicles. VMC DRIVE provides methods to optimize performance in low or no bandwidth areas and uses Local Area Blockchains (LABs) for fast validation of data and transactions between vehicles. VMC will define the future of human mobility.

# Contents

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# 1 Introduction

## 1.1 Current global transportation infrastructure

The global transportation infrastructure is currently undergoing an unparalleled revolution. Major advances in the autonomous vehicle industry, the Internet of Things (IoT) and Artificial Intelligence (AI) are the driving force behind this revolution. Large technology companies such as Google, Tesla and Uber will bring autonomous vehicle technology to the market. Tasks that were once typically human, such as finding an effective route and even steering, will slowly but surely be taken over by computers and algorithms.

Although many actors in the industry understand the importance of Mobility as a Service (MaaS) for the future of human mobility and the development of smart cities, the concepts are still far away from reality. This is due to a poor set of incentives and lack of trust. The current state of MaaS projects can be compared to torrent networks in the late 90's: the underlying technology is solid but it has one fundamental issue; a lack of incentives to provide stability to the network. As a natural consequence, the global transportation infrastructure still contains many imperfections. Some of these imperfections are listed below:

- Ineffective use of roads and vehicles (traffic jams).
- Inefficient use of natural resources.
- Personal data becomes corporate data and is stored in central databases.
- Moderately populated regions are poorly connected.
- Rideshare companies create imperfect markets and create unfair work conditions, for the benefit of their shareholders.
- It is hard for vehicle owners to participate in the Mobility as a Service market.
- Connected (smart or autonomous) cars process huge amounts of data and need very complex algorithms in order to operate.
- Because mobility ecosystems are closed, developers are excluded and innovation is limited to large corporations.

## 1.2 The market

The global transportation industry is a large and crowded market that continues to grow and evolve. People travel every day and the number of movements is increasing dramatically. The number of cars on the road globally will likely double by 2040. There will be even more diversity in the types of vehicles people use to travel; e.g drone, flying taxis and so on. Additionally, the introduction of autonomous vehicles will increase the complexity of our transportation infrastructure because it will create a hybrid situation where both humans and machines are driving. A report by B.I. Intelligence estimates that by 2020 10 million self-driving cars will be on the road [1]. Furthermore, the way people move around is changing. MaaS applications are increasingly used all over the world. This new 'passenger economy' is predicted to be worth USD 7 trillion in 2050 [2].

## 1.3 Blockchain technology

The rise of blockchain technology and cryptocurrencies opens the doors to rethink the mobility market as a whole. In essence, a distributed ledger (better known as a blockchain) is a database. The fundamental difference with traditional databases is the lack of control by a central authority. The database is constantly being verified by a distributed network of nodes. By spreading the ledger over these multiple nodes that constantly come to consensus about the correct state of the database, a verified and immutable record of database changes is created. Since the order of database changes is encrypted, it is near to impossible to alter the history. This creates the possibility to safely transfer digital objects of value and is one of the main reasons of the popularity of distributed ledger technology.

## 1.4 Autonomous Vehicle Technology & the IoT

The IoT is a novel paradigm that supports the interaction between 'things' with complex structures like distributed/grid/cloud applications. Recent advances in IoT have posed great challenges to computer science and engineering. The main issue is that IoT systems have to manage huge numbers of heterogeneous sensors, devices and data types. The case of autonomous vehicles is no exception to this challenge. There are several promising blockchain projects that claim to provide a solution for this problem. Currently however, blockchain technology is still in an early stage, which is why it has been difficult to build actual products on that can

be used by millions of people.

# 2 Problem statement

The human mobility market is huge, growing and in constant development. In order to maintain the current speed of innovation, many challenges will need to be overcome. We have taken the liberty to categorize some important challenges into three main areas:

## 2.1 A lack of incentives and trust

A lack of incentives is one of the main reason why the MaaS market is still in its infancy. Car owners have no proper incentives and possibilities to share their vehicles, people have little incentives to share rides and there is no real foundation of trust, paving the way for intermediary companies. Additionally, people have no incentives to drive in an environmentally friendly way, insurance companies have no reasons to change their business models and governments cannot switch to a situation where drivers pay taxes per driven kilometer.

## 2.2 Centralized and closed infrastructures

Most of the current innovations are created in de facto closed ecosystems with their own payment methods, hardware, algorithms and software solutions. The consequence is a non-cooperative game in which actors (like companies, governments and individuals) rarely develop a strategy in which they effectively collaborate in order to achieve the best result for everybody involved. If we look at transportation from a Game Theory perspective, a Nash equilibrium [3] can never be achieved if all vehicles act purely in their own interest. In order to reach this equilibrium, vehicles need to communicate and adjust their strategies to the strategies of other vehicles. Meanwhile, people and the environment suffer from the consequences. Resources are being wasted, the environment is polluted, road safety is far from perfect and traffic jams are still a fact of life.

In these centralized ecosystems, an exponential amount of personal data is stored. It is remarkable that once a person uses an application, some people consider it to be normal that private data becomes corporate data. This data is monetized to benefit shareholders and governments. Up until now, people had no other option than to trust companies and governments with their data. Even if we could

trust the ethical standards of these companies and governments, there is no guarantee against hacks and data leaks. Another consequence is that these data 'owners' can use this data to develop intelligent algorithms, whereas smaller companies or individual developers do not have the means to do so. This cuts down the amount of possible innovation, collaboration and increases the gap between big corporations, governments and people.

### 2.3 Data processing efficiency & the current state of blockchain technology

With the rise of the connected car and autonomous vehicle technology, a problem is to be expected with the current standards and methods of data processing. Autonomous and other IoT connected vehicles gather huge amounts of data through their many sensors. These vehicles constantly transfer this data to and from centralized databases. Most of this data is state data (vehicle location, health, etc). In order to provide scalability to the industry, new techniques need to be developed.

Blockchain technology and mobility are a natural fit. However, most blockchain platforms are not ready to support the development of a global mobility network as it would likely require thousands of transactions per second (tx/s) in capacity. For many blockchain applications, a transaction rate of 10 or 20 tx/s is perfectly fine. For mobility services however, a transaction needs to be completed almost instantly. People cannot be expected to wait for a minute just for a transaction to be verified when taking a bus or taxi. Proof of Work (PoW) and Proof of Stake (PoS) algorithms are great innovations, but they come with speed and scaling issues. Directed Acyclic Graph (DAG) protocols are very interesting, but they are currently not mature enough to build scalable and reliable applications on.

## 3 Solution statement: VMC

We introduce VMC CORE: a blockchain platform that is designed for mobility services. VMC CORE is fast, secure and decentralized by design. VMC CORE uses the PoET consensus algorithm (PoET); an algorithm that runs on trusted execution environments. The result is an extremely reliable and fast ecosystem. VMC also provides a vehicle communication standard and framework for autonomous vehicles. The VMC technology stack is fully open source.

## 3.1 The creation of an autonomous economy for human mobility

For the MaaS market to evolve to the next phase, we need to be able to easily share resources and provide incentives to do so. We need to replace the system of ownership and control with a system of sharing and governance. VMC believes in a tokenized, decentralized and autonomous economy. Passengers, drivers and vehicles are connected directly to each other, without the need for an intermediary company. This creates an honest marketplace in which passengers, drivers and vehicle owners can all benefit. Other actors such as insurance agencies, vehicle manufactures and public transport companies can also join the network. In order for this economy to be a success, adoption should be easy and independent of the innovation rate of the industry. Therefore, we want to connect non electric vehicles (bikes) and older types of vehicles (old cars and busses) as well. This is important for mobility challenges in both large cities and lesser developed areas. VMC has developed a mobile driver wallet (as a downloadable app and as a cheap hardware terminal) that can be used to connect these vehicles to the network. The VMC wallet can also be integrated inside vehicles. A stable network token is deployed in order to fuel the transactions and provide the right incentives to all actors involved.

## 3.2 Decentralization, privacy and interoperability

An autonomous economy is built on a decentralized network that is powered and controlled by the community. VMC is decentralized by design as transactions are validated by trusted nodes. The main nodes will be hosted by privacy organizations and trusted organizations. On a lower level, 6 out of the 8 CPU's in the check-in terminals deployed by VMC and other companies will also be able to deliver processing power and run network validators. As such, every vehicle using our check-in terminal will act as a node in the network.

By providing users with a self-sovereign identity within the network, transactions are anonymous by default and the control of personal data is put back in the users' hands. A benefit of blockchain technology is the fact that it allows interoperability between all involved actors. Because there is no need for an intermediary company providing trust, all actors can securely interact and transact with each other.

### 3.3 A framework and specification standard for autonomous vehicles

VMC is developing a framework and specification standard for data communication, storage and processing in and between autonomous vehicles. By splitting data and optimizing data validation, we can drastically reduce bandwidth and increase the effectiveness of the data generated and required by autonomous vehicles. Our solution also provides methods to optimize performance in low or no bandwidth areas as transactions will only be communicated to the network, when it is possible or necessary. We use local area blockchains (LABs) for fast validation of data and transactions between vehicles. These local area blockchains communicate with VMC CORE.

## 4 VMC technology stack

### 4.1 General concept

To facilitate the next phase of human mobility, we need a fast, secure and scalable blockchain platform. This is why we are developing VMC CORE; a fully decentralized and open source blockchain, designed specifically to meet the requirements of mobility services. The VMC CORE is designed with a focus on scalability. Transactions can be processed in parallel, decreasing block creation and validation time.

### 4.2 Entities in the VMC network

There are two main entities in the VMC network: users and nodes. Users in the VMC network can be subdivided into two types of users: passengers and drivers (human or machine). Both users are able to use the network to transfer funds or run smart contracts. A node is an entity that is responsible for running VMC's consensus protocol (PoET). Nodes will receive a reward in `VAI` for this service.

### 4.3 Permissioned vs permissionless

In permissionless blockchain networks (such as Ethereum), a smart contract runs on all nodes. All these smart contracts are stored in an Ethereum Virtual Machine (EVM) within a blockchain network and are executed according to certain conditions. When there are many smart contracts running on the network, performance

problems will occur. The most problematic issue is that miners within the network may prioritize running smart contracts from which they can gain higher profits.

To guarantee the speed and quality of the VMC CORE blockchain, VMC CORE is a permissioned blockchain that builds and runs a trustworthy environment for smart contract execution. VMC CORE is open for all mobility related projects. VMC CORE is a platform that not only ensures security and transaction finality, but also increases efficiency through the use of nodes within namespaces.

## 4.4 VMC CORE

The VMC technology stack uses the Hyperledger Sawtooth framework as a technical foundation. Sawtooth is an open source and modular platform for building, deploying and running distributed ledgers. Sawtooth is created by Intel and the Linux foundation under the Hyperledger umbrella. Sawtooth is one of the most robust and secure blockchain solutions to date. Two important elements of the Sawtooth project are 1) the pluggable consensus protocol and 2) parallel processing. Combined, these elements create a strikingly future-proof setup. The main components of VMC CORE are listed below:

- **API** - Converts a request into the right format and sends that to the back end. The public API connects to the back end. It runs security checks before the information is communicated to the blockchain.
- **VMC back end** - Transfers all data in real-time to the right components through Socket IO. The back end additionally handles business logic of applications, like for example the state of vehicle check-ins and outs.
- **Validator** - Validates batches of transactions, combines them into blocks, maintains consensus with the network and coordinates communication between clients, other validators and transaction processors. Much of the actual validation is delegated to other components, such as transaction processors and the active consensus module.
- **Wallet (client)** - A software wallet that communicates with the blockchain. The wallets will ensure a user friendly way of transacting and consulting the blockchain state. They will be available on desktop and mobile. We integrated the wallet in the mobile app for VMC GO, inside the VMC terminals for public transport and will do so inside vehicles.

- **Transaction processor** - Processes payloads of its own transaction family. If multiple transaction families exist, the validator will select the appropriate transaction processor to communicate with. These processors can be seen as smart contracts that are used to implement the business logic onto the chain.
- **Blockchain state** - Holds an immutable history of all transactions that are done.

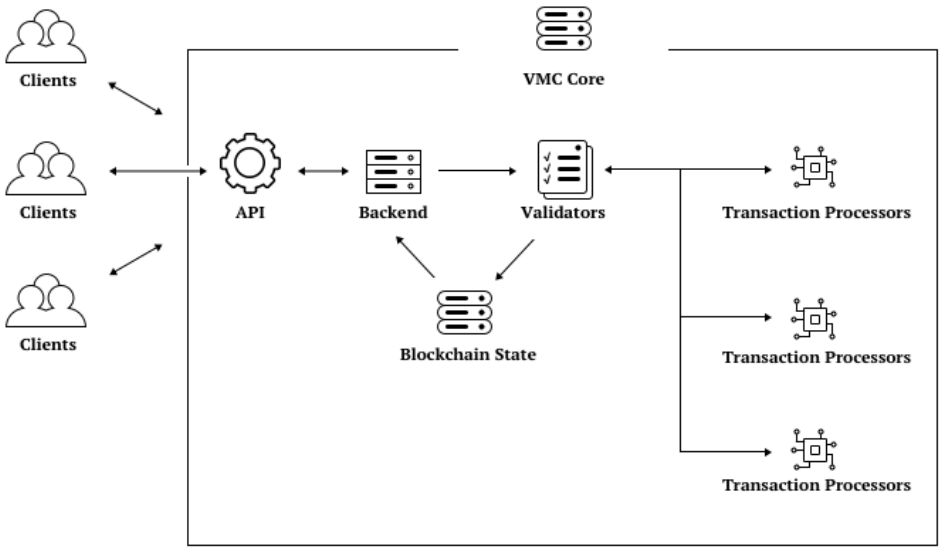


Figure 1: An overview of the VMC network ecosystem

## 4.5 The Proof of Elapsed Time (PoET) consensus method

The consensus algorithm that will be used is called Proof of Elapsed Time (PoET) [4]. PoET elects individual peers to execute requests at a given target rate. These individual peers sample an exponentially distributed random variable and wait for an amount of time dictated by the sample. The peer with the smallest sample wins the election.

Because PoET is executed in trusted execution environments on the instruction set on the processor itself, the consensus can be reached very effectively. Because of the validation on the instruction set, PoET cannot be tampered with, while maintaining Byzantine Fault Tolerance. Using PoET ensures the finality of transactions. PoET offers the security of PoW, but is cheaper and more efficient to use. This low cost of participation increases the likelihood that the population of validators will be large, increasing the robustness of the consensus algorithm.

## 4.6 Decentralization

True decentralization is difficult to reach. However, VMC's design makes it a logical consequence, resulting from the geographical distribution of vehicles and users, decentralization. We define three levels of decentralization.

- **VMC nodes** In the beginning, when the network is new, the network will run on nodes owned by VMC and by selected individuals. This is necessary to guarantee the security and stability of the network. Quickly other nodes will be run by trusted privacy orientated organizations and selected individuals from the VMC communicty. In the future, any individual or company will be able to run VMC nodes.
- **VMC Local Area Blockchains / LABs** The local area blockchains are part of VMC DRIVE. They provide swarms with validated information from the network and vice versa.
- **VMC Terminals** The VMC terminals have processing power, which they do not always fully use. This processing power can be used to create consensus, creating an immediately distributed network.

## 4.7 Transaction fee

To incentive people and organizations to run nodes, a tiny transaction fee in VAI will be charged. The transaction fee is based on the size of a transaction. The goal of this transaction fee is to compensate for the energy used by the processors to validate transactions.

## 4.8 Smart contracts

One of the best things about the blockchain is that, because it is a decentralized system that exists between all permitted parties, there is no need for intermediaries (middlemen) and it saves time and conflict. In 1994, Nick Szabo, realized that decentralized ledgers could be used for smart contracts. The name smart contract can be confusing. The strength of smart contracts is that they are self-executing and therefore guarantee a very specific set of outcomes. They are in fact agreements that are converted to computer code. With the use of smart contracts, anything of value can be exchanged in a safe, transparent and conflict-free way, while avoiding the services of middlemen.

VMC will deploy various smart contracts to smoothen the agreements between all actors involved in the network. Besides smart contracts that implement transactions, smart contracts can be made for specific scenario's; insurance payouts, incentives for environmentally friendly road behaviour and so on. One of VMC CORE's biggest strengths is that it allows other developers, organizations and companies to deploy smart contracts. This enable these entities to easily develop their own mobility solutions, with their own set of specifications and incentives, while taking advantage of the blockchain technology's other strengths.

The VMC CORE uses C++ transaction processors. Developers can deploy C++ smart contracts to communicate with the VMC GO back end. Since everything else basically compiles back to C/C++, using C++ as a language decreases the transaction time.

## 4.9 Anonymity

We strongly believe that individuals should be in control of their own data. A popular misconception is that blockchain technology is fully anonymous and untraceable. While public keys are not necessarily linked to a user's real life identity, every transaction that public keys create can be linked back. This means that if someone were to make the link between you and your public key they would have insight in all your transactions. To ensure users have complete control over their personal data and transaction history, the traditional public-key-as-identity is not sufficient. To manage identities within the network, we aim to use Hyperledger Indy [5]. Indy is a project that provides a distributed-ledger-based foundation for self-sovereign identity and will be used to give users complete control over their personal data. For every party the user interacts with, a new Pairwise-Unique Identifier (public key) is used. By having independent pairwise relationships, the ability for others to correlate your activities across multiple interactions is significantly reduced. Using project Indy, people can for example deliver a verified proof they have a drivers licence, without actually handing over the drivers licence to a third party.

## 4.10 Hardware requirements

Even though the VMC network's is accessible through the REST API specification, requirements are different per application which might depend upon custom hardware. For applications build on VMC GO, we might require dedicated hardware (the VMC terminal) for transaction handling and extra sensors for validation

and network communication. This hardware can be built using custom solutions, like secured embedded Linux systems which are purposely build for this specific application.

The second platform that we are building, VMC Drive, is a full custom solution for autonomous vehicles, making hardware an integral part of the applications. Even though the software will be implemented in a manner that ensures it runs on all Linux hardware, custom hardware might be provided to enable v2v communication. Use cases are custom communication, additional sensors, additional processing power (validation nodes) and screens for visualization of data and necessary information.

## 4.11 Artificial Intelligence

Artificial Intelligence is bound to have impact on almost every aspect of our day to day life. We live in an age where an immense amount of data is stored. With the human eye, it is hard to find usable information within this data. Using intelligent software and algorithms, trends and important patterns in data can be found and put to use with more ease. The fundamental problem of the current data landscape is that the bulk of data is owned by big companies and that this data is not open to use for everyone. This is where blockchain technology comes in. The combination of blockchain technology and Artificial Intelligence has huge potential. We store data from every trip in a public database. Opening up the possibility for others to aggregate this data and create models based on it will enable a vast amount of new use cases, such as, for example:

- Traffic jam prediction and prevention
- Effective route prediction and collaborative navigation
- (Taxi)ride demand prediction
- Insurance premium estimations and modeling

With a little bit of imagination this list can be easily expanded. By enabling everyone in the community to train their own models on this data, we strive to develop a truly efficient transportation network.

### 4.12 Sustainability and cost reduction

As mentioned before, the transportation industry has a disastrous effect on the environment. The transportation industry alone is responsible for 14% of greenhouse gas emissions [6] . Shifting to more sustainable ways of transportation is therefore a pressing issue and the VMC network will help facilitate this. By using the power of artificial intelligence, increased efficiency in resource-usage and new ways of travelling, the network will work to reduce the ecological footprint of our day-to-day travels.

## 5 VMC GO: an open and decentralized marketplace for human mobility.

### 5.1 General concept

VMC GO is an open mobility marketplace platform, free for everyone to access, to generate revenue on and to build applications on. VMC GO eliminates the middleman and creates a more honest marketplace. Mobility services will become cheaper and more effective. On the supply side of the VMC CORE marketplace, people can generate `VAI` tokens by connecting their vehicle to the network and sharing it with the community. Other types of actors such as taxi companies, public transportation companies can also join and offer their services. On the demand side, people will have access to more services and vehicles in a marketplace where there is no middleman. We applaud and enable mobility related innovations by letting developers build on the VMC GO API.

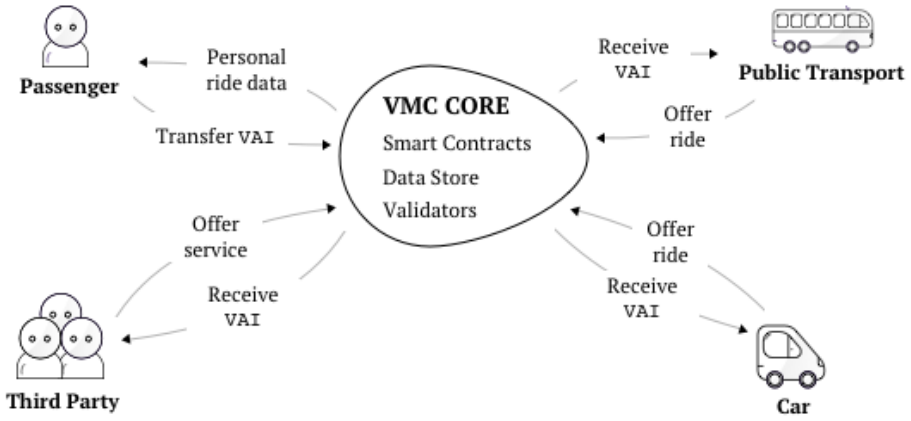


Figure 2: An overview of ***VMC GO***

## 5.2 Current pilots on VMC GO

The VMC team is currently building the first applications on VMC GO. The first example application we build on this marketplace connects passengers with public transport in the Netherlands. There are three main reasons to do the market entry via the public transport market. Firstly, there is less innovation in this domain compared to the private markets for transport. With the application of the VMC infrastructure, we can foster new developments and cooperation between companies and governments. Secondly, using our technology, we can improve the connection of areas that are currently lacking a decent connection with on demand public transportation services. The application will be open sourced and can be used as a framework for whitelabel purposes. Thirdly, in the Netherlands (where we are located) there are some issues with the current payment system for public transport, mainly in terms of data management and interoperability of the payment systems of different public transport companies. These companies are looking for alternatives and we aim to provide one to them. Even still, compared to the public transport and payment infrastructures of other countries, the Netherlands is very advanced. This perfectly illustrates the market opportunity that VMC is going after, as applications based on VCM Go will be able to provide for incremental innovation on a global level.

The VMC mobile application will be extended to support more mobility solutions and services over time. Through the VMC mobile applications, users will be able to order rides and vehicles will be able to join the network to offer their ser-

vices. Because both individual car owners and big companies can join the network, a fair and competitive market is established. The open, peer-to-peer structure of the market creates for near-perfect market conditions, facilitating healthy competition between mobility service providers. Autonomous vehicles, owned by companies, communities and private individuals, will be connected via a vehicle wallet and will be able to join the network in order to find passengers. On the other side, users will be able to request a ride through the VMC mobile application. By broadcasting the request over the network, the vehicles can independently bid on the request. Users can subsequently select which vehicle to use based on price and history of the vehicle. Additionally, these rides can be insured by insurance companies that bid on the rides. After successfully completing a ride, a verified record could be shared with, for example, tax authorities.

## 5.3 Adoption

In order for the MaaS to become a success, actors in the industry must work together. VMC will facilitate this by creating a network in which everyone can order and offer mobility services. Existing car sharing companies can develop and deploy their own applications on our network. The design of our network allows them the freedom to design and implement their own business models and subsequently deploying their dApps on our blockchain, with all the advantages that come with it. The network is open for new players to join and together we will grow the network. A portable vehicle wallet (see section 7.8) is created in order to ensure adoption in lesser developed areas.

## 5.4 Trustless cooperation with third parties

The fundamental principles of the VMC network open up the possibility for trustless cooperation with third parties. The immutable nature of the blockchain enables parties to interact with each other without having a central authority providing trust. Two examples of this trustless communication are given below.

Firstly, since some users would like to share a number of trips that are linked to their account, i.e. for tax reasons, this option is provided as well. By saving a history of transactions in the user's wallet, a verified record is created. This record could be shared with tax authorities as a verified history of business trips. Every year, a great amount of business trips are still registered by hand. By creating a verified database of business trips, the bulk of this manual work could be avoided.

Securely handing over your verified business trip history to the tax authority would be enough, saving the passengers and tax authorities hours of work and money over the year. Additionally, this would also increase trust between tax authorities and business travellers as fraud could be reduced.

Secondly, VMC gives insurance companies the opportunity to insure rides instead of cars or humans. People should not have to pay high premiums for vehicles that are not in use. The development of an auction model where insurance agencies can insure rides when they come available is an option. Insurance companies can place a bid on the ride and the best bid will win. This way, consumers will be guaranteed the best price at any moment. This alternative business model might prove important for insurance companies in a future where MaaS models become of increasing importance.

# 6 VMC DRIVE: a framework and specifications for autonomous vehicles

## 6.1 General concept

The future of transportation lies within autonomous vehicles. A better framework and standard for data communication, storage and processing in and between autonomous vehicles is needed. Without such a standard, an efficient transportation infrastructure that fits the smart city concept will not come into fruition. VMC is currently investigating a solution by combining distributed ledger technology, smart contracts, artificial intelligence and autonomous vehicle technology.

## 6.2 Communication protocol

For autonomous vehicles, there is a massive bottleneck that needs to be solved, which is the exchange and efficiency of data communication between vehicles and their back ends. A big part of the issue is centralized databases, which have complex infrastructures to manage the amounts of data being processed. VMC DRIVE is a framework and specification that can reduces the amount of data management needed and increase the efficiency of autonomous vehicles. On top of that, it provides a smarter system for communication between cars in perfect and imperfect situations. Because cars can share validated information with each other, the necessary complexity of the algorithms that steer autonomous vehicles can be reduced.

This will drastically increase safety on the road, while also decreasing negative effects on the environment.

Currently, car manufacturers are developing their own systems for autonomous vehicles where no communication method is used between cars and no data is shared to other manufacturers. VMC Drive will provide a single open source standard that will solve data management and make the transportation infrastructure more efficient and secure. It enables the creation of local networks. Within these networks, data is constantly being shared. Only relevant data will be transmitted to VMC CORE. By creating a smarter solution using a combination of blockchain technology and smart p2p protocols, the inefficiency of current transportation can be greatly reduced. Through intelligent data sharing algorithms, vehicles will discover their surroundings and interact with each other constantly.

## 6.3 Car p2p solutions

To limit the amount of data transfers and increase awareness of nearby autonomous vehicles, micro-networks can be utilized to handle things like car status messages (OK, Error Codes) in Inter-Car communication networks (Node Swarms). Communication will be done over a smart p2p protocol that is optimized for real-time communication. This scales well in low and high bandwidth scenarios and uses sharing of data between cars to optimize data validation for security, while keeping the data flow within the Node Swarm and keeping data propagation to the blockchain ledger as low as possible.
Feature set:

- Full p2p (many to many relations)
- Load distribution for provided data
- Reduced bandwidth usage
- Priority system for complete and incomplete data
- Extremely fast for small datasets (for real time data)
- Data has lower chance of getting compromised due to the smart data validation
- Can provide anonymous (non-ip based) communications

## 6.4 Car traffic jam and road flow optimization

VMC will not build new algorithms for the actual navigation and steering of autonomous vehicles. Instead, we build a framework and standard that allows vehicles to communicate with each other, using the concept of Node Swarms. Since the Node Swarms provide a way to do fast communication between cars, techniques like movement interpolation/extrapolation can be applied to make the vehicles aware of the others around it. This can be done by approximating speed, trajectory and actions. By adjusting on absolute positions through GPS, cars will be able to drive and navigate more efficiently. Even though the system has a fallback to internal sensors whenever panic situations occur such as emergency braking or obstacle avoidance, it drastically reduces data overhead and bandwidth for the internal sensors, while providing an adequate system for better road flow. Within the individual Swarms, cars can cooperate in order to provide better traffic expectations, reduce traffic accidents, effectively handle unexpected traffic jams and solve the lack of collective awareness.

## 6.5 Blockchain based data validation and storage (Smart Database)

Data accumulation and processing is a big problem for smart car infrastructures, especially when using traditional centralized SQL type systems. Blockchain databases can be used to more efficiently store and verify data using decentralization. All blockchain servers will be localized to an area to contain information regarding traffic and can even be extended to share data-set optimization for the autonomous systems of the car. The area based servers will use online communication to sync relevant data and use its own set of validators to check and recheck data for relevance and sharing. As a consequence, we make blockchains more efficient by moving many processes off-chain, while still retaining a blockchain's characteristic trustworthiness.

## 6.6 Smarter bigdata

Since our pool of data from the blockchain ledger has been pre-processed, validated and optimized before sending it back to the cars, we can introduce smarter data with less memory footprint. Certain moments of communication can be used to transfer the data:

- Startup of the car

- Moments during high bandwidth availability (High Quality 4/5G connection, WIFI spots at charging spots/gas stations)
- Shutdown of car as background process when enough power is available

The data can be distributed from either the blockchain ledger or other cars it connects to when part of Node Swarms.

## 6.7 The VMC Smart Car specification

In order to further optimize this, an Open Source specification for inter-car communication is necessary to standardize communication of cars regardless of vendor. This standard will be proposed as an ISO Standard to ensure that a basic Open Source Standard (OSS) implementation is available for all vendors. Consequently, this will enforce collaboration on road safety due to sharing of essential data and combining resources for security and stability of the network. The VMC Smart Car specification will go over methods of communication between cars, a standardized packet format (using the Protobuf standard) and a functional implementation of the system. While autonomous vehicles are the future, there will be a moment in time when there are human drivers and non human drivers on the road at the same time.

## 6.8 Shared data and ethics

Using the smarter data described above, autonomous vehicles could learn from what other vehicles did in edge case scenarios. Because it is impossible to implement rules for every possible situation on the road, vehicles will need to adapt to new situations constantly. If these new insights were to be shared between vehicles, the whole vehicle infrastructure would become safer and more equipped to handle unforeseen events. It would also provide us with a solution for an unintended consequence of centralized autonomous vehicle ecosystems: a competition between ethical standards. It should never be allowed for people to use or buy an algorithm with more selfish standards compared to others. Shared ethical standards provide insurance agencies and other involved actors with an improved concept on the “who is to blame” problem in case of an accident. Smart contracts can act as a verified source of truth that could detect who was at fault in a crash; the sensor or the driver, as well as countless other variables.

# 7 VMC tokenoconomics and a community driven mobility economy

## 7.1 General concept

As a result of Satoshi's white paper, we have learned that through the clever combination of incentives, cryptography, networking theory and computer science, we can build new kinds of technologies and independent economies. To operate fully independent, these economies need a token to operate. The term cryptoeconomics and tokenomics are often referred to as a new kind of economics and even a new field of science. We perceive cryptonomics from a mechanism design point of view, a field related to game theory. Cryptonomics in this way can be seen as reverse game theory because we start with the desired outcome and work backwards to a design that provides actors with the right incentives to act in line with the interests of the network. For VMC, the desired outcome is the creation of a self imposing Nash equilibrium.

## 7.2 Purpose and usage of the VAI token

The primary reason for the introduction of the `VAI` token is to facilitate the development of an independent mobility economy. It provides incentives for actors that attribute to this economy and it fuels the transactions within the VMC network. The current version of the network already provides authenticity checks and ownership registration. A token namespace and a token transaction family are implemented within the VMC Blockchain. By combining a token transfer with, for example, a data request from another car, value can be transferred between entities, while ensuring the value is only transferred when the data request is honored.

## 7.3 Stability inside the network

Stability inside the network is important. Users should be able to pay and get paid in a frictionless fashion. Companies should be able to build solid business cases, without the currency/volatility risks. In the early days of many blockchain projects, we often see high volatility in token value or quick sellouts on crypto exchanges. Projects sell utility tokens in advance (via a private tokensale) and use the funds to build a project. It disrupts the venture capital industry because it allows a group of smaller investors to generate possibly interesting returns. This token sale model has

a number of challenges [7]. The main challenge for legitimate tokensale projects, is that the tokensale comes with a set of incentives that are counterproductive:

- **Team and early investor incentives:** The team that is executing the project has little incentives to perform at its best, because of the influx of capital realized by the tokensale. The investors that bought in at a discount have incentives to sell the token, not to hold it. This creates an unfair situation to retail investors and users. Even if tokens reserved for the team, advisors and early investors are locked up in a smart contract for a limited amount of time after the token sale, the supply of tokens will increase dramtically from the moment these tokens are released, resulting in a sharp decrease of a token's value.

- **Centralization of utility:** The challenges as described above can be seen from a agency theory [8] perspective. The agency problem teaches us that we have to align the interests of the tokenholders with the interests of the project and vice versa. Bitcoin solved this problem perfectly; it provides incentives for everyone to attribute to the success of the ecosystem. In terms of a public tokensale, VMC will use a different approach that is designed to develop an autonomous economy. All actors in the economy should be incentivized to make the project a success.

## 7.4 Dual token structure

VMC recognizes the fact that investors have different interests than to people who use the platform to travel or to build businesses. Our goal, as a company, is to build a company an open and decentralized marketplace for mobility services. For such a marketplace to function properly, we have to design it in accordance with the needs of its stakeholders. Of course, for users it would be ideal to use a token that is not subject to any volatility. If a traveler is to put 10 euros worth of tokens in his or her wallet, that person wants it to still be worth 10 euros when using it to travel. At the same time, businesses want to be able to predictably calculate and project their revenues and profits. As such, a stable coin is required for both of these stakeholders. Investors, on the other hand, are more interested in generating a return on their investment, which is impossible with a stable coin. As these interests are completely incompatible with the interests of other stakeholders, VMC has decided to implement a Dual Token Structure, with each token catering to the

interests of different stakeholders.

- **VMC-ST:** Investors can participate in the project via a security token: the VMC Security Token (VMC-ST). Each VMC-ST represents economic rights in VMC.ai B.V. in the form of a revenue share. A defined portion of all revenues from the VMC Core platform is distributed to VMC-ST holders. The relationship between VMC.ai B.V. and the token holder is of a contractual nature under the laws of the Netherlands. No offer is made to investors in any jurisdiction in which it is unlawful to make such an offer.

- **VAI:** The VAI is a stable-coin that is issued and maintained by the VMC Foundation, which is an independent foundation which is further responsible for building out the VMC ecosystem and distributing the open-source licenses. Holders of the VAI token cannot expect any profit, as the VAI is solely designed to provide a utility. It will be possible to buy VAI from, and sell VAI to, the VMC Foundation. The VAI will be a fully backed stable coin. It can be used on VMC's mobility platform as a medium of exchange, to facilitate payments on the network.

## 7.5 Governance

While the VMC network is intended to work perfectly from day one, iterations might be necessary when the platform is put to the test. The VMC team has to be able to constantly adapt to any market, technological and scientific developments. At the same time, there must be a form of governance that ensures a strong degree of decentralization moving forward. This is why we have a strong and democratic governance system. We believe that the project should be governed by representatives of the token holders. Token holders are the network owners. It is in the interest of the tokenholders that a project is successful and develops a great business case. This is why we propose the VMC council.

- **The VMC council:** The further the VMC project develops, the more decentralized the VMC network will become. As a consequence, there can not be a single authority that governs the project. The council has the right to vote on certain decisions and can bring topics to the agenda. The VMC council will be led by individuals who are selected from several industries such as mobility, blockchain technology, economy and computer science. Eventu-

ally, VMC needs to evolve into a Decentralized Autonomous Organization. The VMC council consists of holders of VMC-ST.

### 7.6 Iterations during the project

Projects built on blockchain technology all face similar challenges. One of the most complex challenges is how to deal with technical developments during the project. In a normal situation in digital technology, iterations are common practice. In blockchain this is different: the blockchain is immutable. Smart contracts however, can be subject of change. New smart contracts need to be deployed and amending existing contracts will be necessary when the network evolves.

## 8 Conclusions

In order to let the mobility industry operate and evolve, decentralization will be a key component in the near future. VMC creates the starting point for innovations like resource sharing, shared ethical standards, perfect marketplaces, industry standardization and traffic jam reduction.

Mobility and blockchain are a natural match. The application of blockchain technology provides us with a secure, scalable and anonymous solution. The VMC technology stack is open source and the platform is open for all mobility related projects.

The `VAI` token powers the network, allowing quick and easy transfers of value and data. `VAI`tokens operate directly on the VMC CORE blockchain. All participants in the new mobility economy will have incentives to build an autonomous economy, driven by innovation and collaboration. VMC will define the future of human mobility.

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