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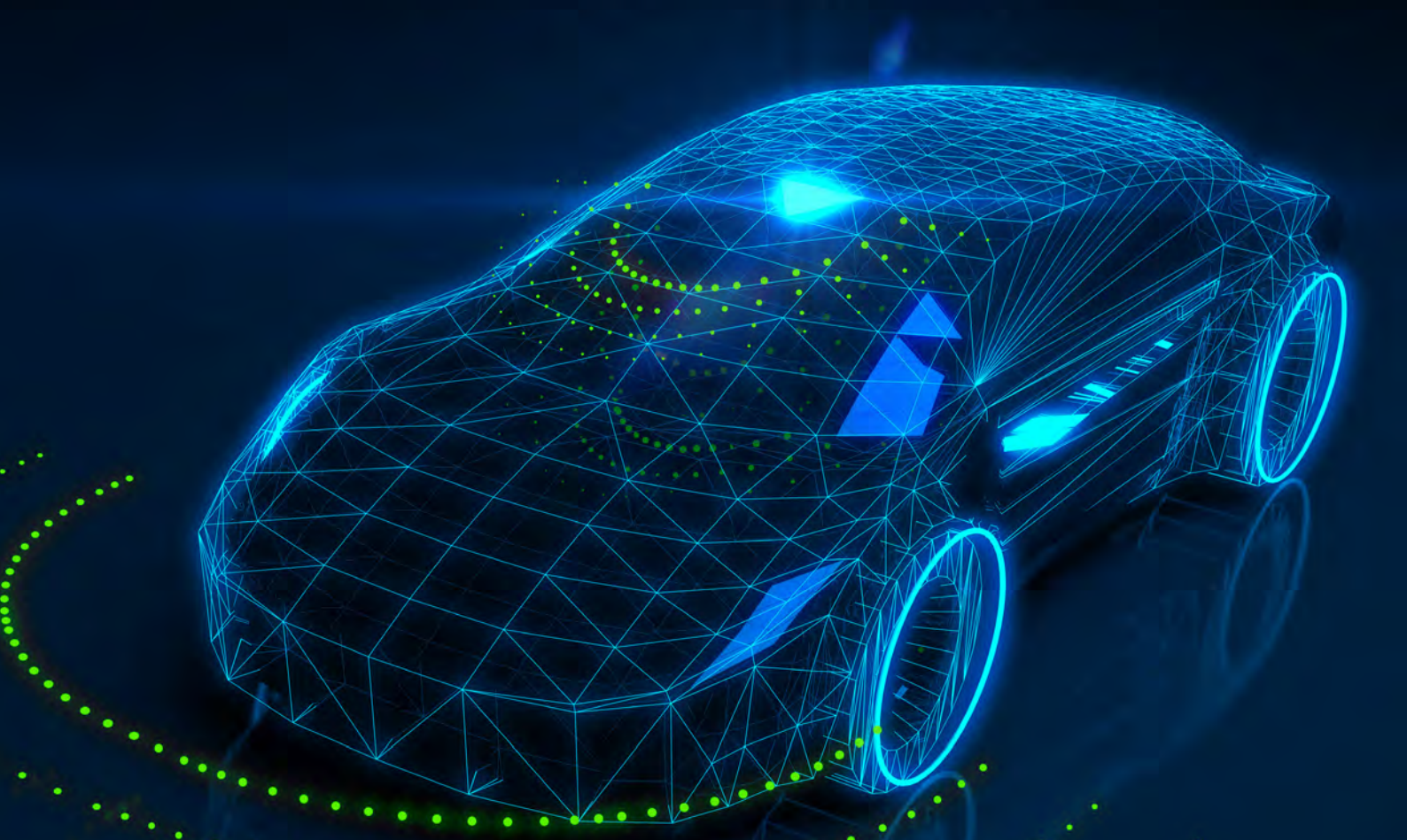


THE AUTOMOTIVE SECTOR AND BLOCKCHAIN

Is Trust what we need to enable the next Generation of Mobility Services?

A JOINT WHITE PAPER BY MHP AND RIDDLE&CODE

Table of contents

DLT vs. Blockchain.

Distributed Ledger Technology (DLT) has a loose definition. A Blockchain is a chain of blocks that is a type of DLT. Some well-known DLTs based are not Blockchains but use different core technologies like the tangle. Theoretically, DLTs need not include cryptography, although no one uses the term that way.

This White Paper does not go deep enough into the technology for the differences to matter, so except in the cases of technologies that aren't Blockchain-based like IOTA, we use the terms interchangeably.

WORD	DEFINITION
Automotive OEM	Automotive Original Equipment Manufacturer, e.g. Porsche, VW, Tesla, etc.
Autonomous Driving Level 4	"mind off" – No driver attention is required in certain areas or circumstances (e.g. traffic jam)
Autonomous Driving Level 5	"steering wheel optional" – No human interaction is required at all (in all areas and circumstances)
AV	Autonomous Vehicle
DMV	Department of Motor Vehicles (US) or in Germany the "Kraftfahrtbundesamt"
DSRC	Dedicated Short-Range Communication: one-way or two-way short-range to medium-range wireless communication channels specifically designed for automotive use
EnWG	German Energy Industry Act (ger. "Energiewirtschaftsgesetz")
GAFA	The Big Four tech companies: Google, Amazon, Facebook, Apple
GDPR	General Data Protection Right
M2M	Machine-to-Machine (communication)
OTA Updates	Over The Air Updates: are a wireless delivery of new software or data to connected devices
RSU	Road Side Unit: Computing device located on the roadside that provides connectivity support to passing vehicles
Self-sovereign identity	A digital identity approach that focuses not only one WHO someone or something is, but also on WHAT they can do and WHAT can be done with their data attributes
TCU	Telematics Control Unit
Truck Platooning	Is a link of two or more trucks driving in a close distance in convoy to make transportation more efficient, safe and clean. They use connected communication technologies and automated driving support systems
V2C	Vehicle-to-Cloud communication
V2I	Vehicle-to-Infrastructure (e.g. traffic lights, toll stations, roads, etc.) communication
V2V	Vehicle-to-Vehicle communication
V2X	Vehicle-to-X (everything) communication

Glossary

DARING TO BE FIRST – How auto pioneers are taking the plunge into Blockchain

Source: IBM Institute for Business Value 2018

61%

OEMs

Many automotive executives believe that blockchain will be a disruptive force within the next three years

01 Executive Summary

> Tech Giants such as Google, DiDi & Co. will take on the mobility services, so that automotive OEMs will face fierce competition if they do not take that challenge, which is not about building cars, seriously. One answer to that challenge in order to retain resilience against the new competitors are cross-industry collaborations. Especially the combination of OEM customers combined with Energy and Public Transport customers can generate a strong customer base. That's why we work not only with automotive OEMs and suppliers but also with the energy industry and the public sector to create innovative multi modal mobility solutions and ecosystems. We believe that Blockchain technology will be an enabler for this cross-industry collaboration.
>
> Marcus Willand | Associated Partner | Mobility | MHP

What do we want to achieve

- Blockchain technology is highly beneficial for mobility industries in some areas.[1]
- We shall see that decisions need to be prepared and made sooner rather than later.
- A limited understanding of this multi-dimensional new technology and inadequate scoping of projects have led to some frustration for early adopters. Additional research and operational trials are still needed for Blockchain technology adoption.
- Regulators should accept that Blockchain technology increases transparency and trust, much needed after technology scandals in various industries and a global 'trust recession' that is more and more affecting our societies.
- However, now is the right time to take a close and thorough look at this space:
  - The rise of shared mobility services increases the need for efficient settlements
  - Security, efficient exchange and audit solutions will be needed
  - Transaction costs fall with the development of decentralized finance
  - Insurance, charging infrastructure and Smart Cities need to be made interoperable with IoT devices such as vehicles
  - Car wallets, based on a secure ID, will turn almost any physical object into a trusted participant in emerging marketplaces[2]
  - Cryptography and Blockchain offer the security required to entrust them with the life or death decisions of autonomous vehicles
  - Autonomous cars will have to settle Vehicle-to-X (= infrastructure) processes
  - Trustless transaction will grow machine-to-machine -solutions explosively

Blockchain brings secure identity to vehicles and infrastructure, making them addressable. Leveraging DLT also brings trust and enables new marketplaces.

This White Paper is structured into five main components. We'll first look at the current automotive situation and mobility trends with a theoretical description of 10 use cases. Then we'll explore when Blockchain makes sense for the automotive industry with a zoom into the car wallet. In chapter 4, the current Mobility Blockchain landscape is described with real-world use cases based on (mostly) commercial products. Before the final summary, chapter 5 takes a look at the future of the automotive industry and what new business Blockchain might bring by enabling trust.

1 This might be seen as a bold statement, but our focus in this study is more on the 'how' and less on the 'why'. Other recent studies that used survey automotive managers came to very similar results about the expected use and importance of Blockchain for several mobility industry sub-segments, see e.g. IBM Institute for Business Value 2018, Daring to be first – How auto pioneers are taking the plunge into Blockchain

2 Jaguar Land Rover published an estimate that 75bn devices will be connected to 'Smart Wallets' by 2025. While their definition of those wallets might be a different one compared to the Hardware Car Wallet that we will talk about in this whitepaper, the dimension they state is certainly an indicator of the paradigmatic shifts ahead of the industry.

02

Current automotive situation and mobility trends

> The mobility sector is changing from a product business into a service one. Successful services always focus on the user, and new solutions must address both passenger and freight transport. The future of Mobility is digital, and that's why today's OEMs need to completely rethink their business models to survive in this data-driven era.
>
> Nils Schaupensteiner | Manager | Mobility Expert | MHP

We are heading towards an industry that is more and more connected. The mobility sector is experiencing a rapid change in prevailing market demands and trends that had dominated the industry for decades. The traditional idea of everyone owning their own car as the primary means of individual mobility is moving towards more opportunity-based and interconnected modes of transportation. Public transportation, car sharing or simply hiring a personal driver for short distances are more common. Alternative last-mile mobility means such as fleets of electric scooters, shared electric vehicles, and autonomous ride-sharing offers are also growing. It becomes evident that ownership of mobility develops towards the usage of mobility. The emerging modes of mobility all imply common challenges that the automotive sector has to face to operate connectivity and service-based business models.

Today's mobility platforms are developed to meet people's need for mobility solutions – particularly for last-mile distances – providing multiple solutions. These services are primarily driven by new market entrants. The new platform-based business models connect people to services. Specialized non-incumbent companies have divided the market among themselves. Recently, automotive OEMs have started launching initiatives that reach beyond their core competency of developing and manufacturing cars. New services range from connected and personalized vehicles (e.g. BMW Connected or MercedesMe) to establishing electric charging infrastructure (e.g. IONITY). Despite new services and an alteration in market demand, OEMs are increasingly shifting focus away from conventional combustion drive technology towards hybrid and electric powertrains. The introduction of new core technologies requires new competencies and meeting new challenges along the way. New services and specifically more and more connected vehicles raise the question of security, reliability, and traceability of data. The immutability of information, digital identities and payments become crucial for the sustainable success of new data-driven business models and services. Distributed Ledger Technologies (DLT) meets the challenges of data immutability in a mobility service context.

The automotive industry has started to address the challenges of data immutability, from new technologies and business model exploration. in the following paragraphs we have compiled a non-exhaustive list of current trends and scenarios in the automotive industry. We intend to identify recent and upcoming challenges in the secure use and appliance of data in new services and business models in the mobility sector. As an overall structure for the different scenarios, we use the well-established "CASE" or as used in academics "ACES".

This chapter 2 sets the scene for where Blockchain may be used without describing it. Chapters 3 and 4 will introduce Blockchain technology and how it facilitates some use cases.

C for Connected

A for Autonomous

S for Shared, Services, Subscription, Software

E for Electric

C for Connected

According to a study by Strategy&[3], by 2025, there will be in total more than 425 million connected vehicles in Europe, the US and China. Connectivity does not only apply to in-vehicle connectivity through the infotainment and communication system such as Apple CarPlay but also to Vehicle-to-X communication, whether it is vehicle-to-cloud (e.g. over-the-air (OTA) updates or payment transaction settlements), vehicle-to-vehicle (e.g. truck platooning), or vehicle-to-infrastructure (e.g. traffic lights or electric charging stations).

[3] PwC 2017, The 2017 Strategy& Digital Auto Report

Use Case A: Vehicle-to-cloud (V2C)

Faster technology lifecycles and the gap between the vehicle hardware product development and iterative, agile development of software requires frequent remote software/firmware updates of car components, especially with autonomous vehicles. Over the air (OTA) updates and maintenance help prevent recalls or recurring repair shop visits. Besides updates and bug fixes, OTA also allows users to upgrade car features such as a lane-keeping assistant or extra horsepower on demand.

Use Case B: Vehicle-to-vehicle (V2V)

Vehicle-to-vehicle communication is the key for autonomous driving and other use cases such as platooning because it allows vehicles to communicate quickly, safely and securely. This way, vehicles can share information to alert drivers or other vehicles to prevent collisions through automated emergency braking systems. Or in the case of Autonomous Vehicles (AV), to request an overtaking. The communication can be either via cellular services such as 3G or 4G and the cloud or directly V2V via dedicated short-range communication (DSRC) up to 300m. DSRC is the technology that is currently predominant in the U.S. connected-vehicle market because it is faster than cellular. In fact, it is prescribed by federal regulators. However, as soon as 5G is available, there might be a shift or complementation of both technologies.

Use Case C: Vehicle-to-infrastructure (V2I)

Similar to the V2V communication, vehicle could communicate with with Road Side Unit (RSU) or other infrastructures such as traffic lights, toll-stations, charging stations and inductive charging roads or highway fast-lanes (vehicle gets automatically billed for using the fast-lane). Furthermore, many safety applications like curve speed warning, reduced speed zone warning, etc. require vehicle-to-infrastructure (V2I) communication.

Use Case D: Data Marketplace

Vehicle data could also be shared and used to improve vehicle services and the user experience. 'Data is the new oil' is a mantra of the new world. Although the metaphor is debatable, the value of data can be seen in the rapid growth of data-driven businesses such as Google or Facebook. Their market dominance not only concerns governments and legal authorities but also automotive OEMs. They fear the dependence on GAFA (Google, Apple, Facebook, Amazon) with regards to connected car and consumer data ownership and the potential loss of parts of future value chains, e.g. digital (in-car) services. Protectionism is not the answer because for many value-adding services, more than the individual OEMs data is needed. Central platforms for connected car data such as High Mobility or Otonomo might be a solution but also pose a potential risk through centralization.

Key challenges for Connected:

Identity impersonation:

Changing the driver's, the vehicle's or the infrastructure's identities to deceive the police in the case of an accident or the OEM in order to download or buy features unauthorized on behalf of someone else

Message suppression:

Preventing the authorities and RSU (Road Side Units) to know about any collision or other vehicles to know about infrastructure information, e.g. road conditions

Data alteration:

Changing or modifying existing data to deceive others or to use illegal vehicle or feature updates

Sybil attack: Providing the illusion of many vehicles to force other vehicles off the road

GPS spoofing: Taking the identity and geographic location of vehicles on the network to fool them

Bogus information: Broadcasting false information to affect the decision of other vehicles, infrastructure or others

Data privacy:

Protecting driver's privacy preferences, their personally identifiable information and corresponding data such as driving data

In the use case of data marketplaces:

Middleman model represents a single point of failure and monopoly of power, especially with regards to the market power of GAFA

Transactions:

Executing micropayments and settlements between vehicles (e.g. in the case of takeovers), between vehicles and infrastructure (e.g. in the case of inductive charging roads) or between data marketplace participants efficiently

Technology maturity:

Comprehensive availability of DSRC and 5G equipped infrastructure and vehicles, and efficient processing of large volumes of data

A for Autonomous

Autonomous driving is a critical scenario for the mobility industry. It will not only have an impact on transportation use cases (e.g. robo-taxis) but also on vehicle ownership and mobility business models. A KPMG study, for example, predicts that in a mobility-as-a-service business model, autonomous vehicles could be up to 40% cheaper than private cars[4]. According to another PWC study, the scenario will be real soon: in China, 35% of new vehicles in 2030 have level 4 or 5 technology.[5]

[4] KPMG 2019, Mobility 2030: Transforming the mobility landscape

[5] PwC 2018, The 2018 Strategy& Digital Auto Report

Use Case E: Autonomous Driving

Due to a growing demand for mobility and at the same time limited infrastructure and because of increasing environmental problems and number of accidents, there is a shift from manually controlled vehicles towards conditional, highly automated and ultimately fully automated (driverless) vehicles.

Not only in passenger mobility but also in freight logistics. However, the transition will take time. There will be a phase of mixed traffic flow of non-self-driving and self-driving vehicles and the requirements for autonomous driving on highways differs from that in urban areas.

Use Case F: Self-Owning-Car

Mike Hearn, an ex-Google security engineer, introduced the concept of self-owning cars in 2013. In a world of fully autonomous vehicles having their own financial entity, those can sometimes earn money by offering a mobility service or spend money for maintenance or infrastructure usage such as electric charging or tolls. Several possibilities exist to initiate financing of the production of self-owning cars. The car could be fully financed by an OEM, suppliers and workers, who would all get a stake in the vehicle. In a second scenario, the vehicle could be funded by general investors who acquire a stake in the car. In both situations, the vehicle can either pay back the investment with interest or pay dividends until its end of life.

Key challenges for Autonomous:

As V2X communication is a prerequisite for autonomous driving, most of the previously mentioned challenges also apply to the field of autonomous driving, especially the challenges regarding information security (confidentiality, integrity & authenticity, availability) and micro transactions and payment settlements

Contractual Capacity:

Currently, business transactions can only be conducted between physical people or legal entities such as corporations or associations because they are tangible and liable. Vehicles or machines, in general, are not legally recognized as neither natural persons nor legal entities

Vehicle as an investment:

(Crowd-) investing in individual vehicles is complex, and still relies on a centralized entity with all its inefficiencies. Furthermore, a governance mechanism is required to ensure that the interests of all stakeholders are considered

Technology and infrastructure maturity:

Managing a mixed traffic flow and the automation of V2X communication

Legal requirements:

New regulations and their impact on liability and insurance issues. Especially after the first fatal self-driving car accident by a car of UBER in 2018, there is a question about who is responsible in the case of a self-driving car accident

Note:

We recently published a white paper dedicated to autonomous driving, the challenges, the impact on automotive processes and the relevant technologies:
https://www.mhp.com/fileadmin/www.mhp.com/assets/pdf/MHP_Autonomous_Driving_EN_2019.pdf

S for Shared, Services and Software

From a focus on hardware to focus on hardware+ (hardware plus software): Automotive OEMs originally produced cars and then sold them directly or via car dealers in cash or via financing. Leasing models came onto the market later. This led to an extension of the OEMs' portfolios. Besides selling products, they know also offered services such as vehicle rentals. Flexibility is required to meet emerging customer needs, for example for subscription-based vehicle rental as can be seen with Porsche Passport or Care by Volvo.
Such services are no longer only car-related, but also include general individual mobility services up to multi-modal mobility-as-a-service platforms such as moovel, which recently became ReachNow. Furthermore, data-connectivity services, such as apps or software upgrades, are creating new revenue streams. McKinsey predicts that new services could create an additional 30% of revenue for OEMs in 2030.[6]

[6] McKinsey 2016, Disruptive trends that will transform the auto industry

Use Case G: Shared vehicles

The idea of sharing vehicles already came up in the 70s. Nowadays, there are three types of car sharing concepts: stationary car sharing (e.g. Flinkster), free-floating car sharing (e.g. ShareNow) and peer-to-peer car sharing (e.g. Drivy) were private car owners can rent their car directly to other persons. All three concepts can also be applied to bikes or scooters and other vehicles.

Use Case H: Traditional vehicle purchase vs. Mobility-as-a-Service and digital services

According to McKinsey, the global car sales will continue to grow, but at a slower pace due to macroeconomic factors and the previously described mobility services such as car-sharing but also professional (e.g. UBER) and private ride-sharing/pooling or hailing services (e.g. BlablaCar). Also, data-connectivity services such as apps or software upgrades and temporary vehicle functions (e.g. improved performance or extended vehicle range, see also use case A) are new revenue streams.

Key challenges for Shared, Services and Software:

Identity impersonation:

Changing the driver's identity and driver's license to deceive the rental company, owner of the vehicle or the insurance

Organisational:

Due to the transition from a product business to service business, traditional control instruments and KPIs used in the finance process no longer meet the requirements of new business models

Processes:

New business models require a change in existing processes and especially a shift of focus to after sales and retail processes

Mobility-as-a-Service (MaaS):

Enablement of seamless mobility without the need for several mobility service provider registrations and different individual tickets

Transactions:

Ensure secure access to cars and secure transfer of (temporary) usage rights not only in terms of mobility usage rights but also in terms of temporary vehicle software features

Legal requirements:

Provable assignment of damages and pollution of the car to the originating user

E for Electric

Since the Dieselgate scandals, the German automotive industry is strongly committed to pressing ahead with the development of electric mobility. Climate protection, a growing scarcity of fossil fuels and an increased need for mobility due to rising population requires new solutions and alternative propulsion systems. But the scope is not limited to electric vehicles. An overall e-mobility system ranges from the electric vehicle and the charging infrastructure to the integration into the smart power grid.

Use Case I: E-Mobility

E-mobility is understood to be the use of vehicles that carry an energy storage unit with them and use an electric drive. Vehicles range from electric bikes and scooters to electric cars, buses and trucks. In the automotive industry, e-mobility has an impact on the whole value chain from vehicle engineering and battery production to sales and after-sales. Currently, the main focus of the industry is on the battery as it is one of the most expensive and critical parts of the vehicle, on the charging process and the overall user experience.

Use Case J: Vehicle-to-grid (V2G)

Privately owned vehicles are most of the time idle and therefore, their batteries work as flexible intermediate storage and buffers. E-mobility could thus be part of the integrated energy grid. This way, battery electric vehicles could, on the one hand, communicate with the smart grid to cheaply buy electricity during oversupply or on the other hand, sell stored power to the grid or throttle their charging rate at high demand peaks. This sector-coupling concept is also called power-to-mobility.

However, at this time, in countries such as Germany, legal requirements such as proof of origin or performance mean that mobile energy storage like EV batteries do not qualify to participate in the controlled power market (ger.: 'Regelenergiemarkt'). Peer-to-peer charging and energy trading will also be possible when these issues are solved.

Key challenges for Electric:

Identity impersonation:

Battery is the most expensive part of an electric vehicle and can easily be counterfeited

Data alternation:

Batteries are highly sensitive, and it is important to comply with recommended charging cycles for safety and capacity reasons

Transactions:

Vehicle-to-Grid (V2G) as a further subcategory of V2X also requires micropayments and settlements

Technology and infrastructure maturity:

Missing infrastructure such as inductive charging roads and bidirectional chargers, which are able to feed electricity back into the grid

Legal requirements:

Complex requirements of directives and laws such as the German Energy Industry Act (EnWG), e.g. proof of origin and proof of performance as roadblocker for mobile energy storage and V2G (accurate and trusted tracking of who produces and who consumes electricity in a grid that is decentralized by design)

03

Meaningful starting points for Blockchain

> Vehicles can become autonomous business entities that participate in transactions on their own. RIDDLE&CODE's Car Wallet makes this happen. OEMs and mobility service providers can then embrace the M2M era and start to interoperate with their neighboring counterparts, such as Smart City or logistics infrastructure providers. Blockchain-driven solutions have financial capabilities by design. Thanks to Blockchain technology, stakeholders in the automotive sector can now own the data stemming from their machines and vehicles. They can then use this to incentivize customers and partners to grow revenues within the nascent tokenized economy.
>
> Alexander Koppel | CEO of RIDDLE&CODE

In this chapter, we'll look into how Blockchain solves some of the challenges described above – mainly by adding trust – and gaze into what some of the new opportunities it might bring to the mobility sector as a whole.

Considering business processes and technology alone cannot create a successful DLT-based project. To be sustainable, whether for mobility or any other sector, Blockchain-based projects must, in the end, create sustainable financial models that can also be tokenized. Machine identity solutions are adding trust and addressability at a new scale, which in turn opens new marketplace opportunities. This is why projects we believe in are not just based on some new hardware and software, but provide holistic solutions where many stakeholders participate in a vertical industry.

Blockchain enables several critical requirements for seamless multi-party business cooperation:

- Trust between the parties involved, because they can
- rely on data coming from machines that are 'trusted Data Sources', because they have:
- tamper-proof digital Machine or built-in Vehicle Identities, established by an embedded crypto chip, but are also
- registered on a Blockchain.

It is this 'pairing' of the physical machine with its digital Blockchain Digital Twin that makes DLT-connected physical objects so secure and powerful for multi-modal mobility and transportation solutions of the future. The hardware-based, highest security approach that was designed with critical infrastructure in mind can offer full wallet functionality at the same time. This can be used to enable additional business models on the service level and will become the basis for machine-to-machine (M2M) settlements, even more so for autonomously driving vehicles. It can also be used at the policy level to incentivize desired behaviors by all traffic system participants. In the shorter term, DLT will help in adding trust and greatly reduce the vulnerability of existing processes such as OTA updates that pose significant security threats to car manufacturers today. These cybersecurity challenges are only going to grow in the era of the connected car, with existing bus systems such as the CAN bus or OBD protocols not being secure enough and technically outdated, yet still crucial to the industry. But until IP-based car infrastructure under AUTOSAR becomes a reality to simplify things in terms of security, vehicles are under the threat of being hacked.

The full security impact of Blockchain will be all the more apparent to the reader when we take into account a future where Autonomous Vehicles (AVs) will more and more be the norm. This will then be a 'critical infrastructure', when not only passengers will have to rely on the technology doing its job reliably. Neighbouring segments such as insurance and smart cities will need to build their services on vehicles that can be held accountable, for example, on their geographical position and data they are sending. After events in recent years, trusting car manufacturers to store, and maybe forward data originating from on-board technology they produce and control themselves may prove to be a difficult message to send to the public. With Blockchain-connected crypto chips at the heart of future 'Car Wallets', private keys – the ultimate identifiers – do not even need to be known by the producer. The chip encrypts data as it comes into existence, ideally at the level of mission-critical sensors, and sends entirely encrypted data streams to secure DLT data repositories. This means that nobody, neither an OEM nor a hacker, can tamper with such a set-up. Blockchain technology also satisfies the public's overwhelming desire to not store unencrypted private data anywhere in the public domain.

Summing up, we see Blockchain playing a significant role in many areas that are relevant to traffic management, including the following:

- Complete (autonomous) transport systems that include private and shared cars, as well as public transport, require trust at the data level. This includes information about the vehicles, their whereabouts, their state of repair, the cost of a journey and perhaps its carbon footprint. Associating vehicles to a Blockchain is the best way to achieve this by securely guaranteeing machine identity and thus turning vehicles into trusted data sources.
- By creating a secure machine identity for vehicles, Blockchain can be a crucial enabler for many of the use cases discussed previously.
- Blockchain's inherently decentralized architecture is a vector of trust, immutability and security, eliminating risks due to single points of failure. The cryptography used increases security and thus trust also.
- DLT-based solutions bring efficiency and cost-effectiveness notably through automated settlements as we shall see in the Car Wallet example below.
- The trust brought about by Blockchain enables incentivization schemes so local authorities, responsible for road safety, can trigger the desired behavior to reduce accidents and pollution through traffic management.
- Improved data – because it is more trustworthy – enables better fleet or multi-modal transport service management and will bring about innovation in car insurance, both at the contract level and for managing claims.
- The technical infrastructure described here, when used within a more ambitious vision, can address the more challenging aspects of future (car-based) mobility solutions. Unifying the complex landscape of bus systems in a car and sustainably connecting vehicles to Smart City infrastructure – an issue that is somewhat 'hidden' behind the 'V2X' acronym.

> Car manufacturers are shifting their roles from being mainly producers of cars to also becoming service providers. They already provide mobility services but in a stand-alone way, lacking a seamless user mobility journey. In the future, there will not be countless different mobility ecosystems, but only a few where all the services will be embedded. DLT could become a common tool for Mobility as a Service, but car manufacturers have to cooperate to define standards, whereas they simultaneously will not lose the opportunity to compete. "Coopetition" is what they have to achieve.
>
> Dr. Klaus Schaaf | Distributed Ledger Evangelist | Volkswagen AG

Standardizing Vehicle Identities

But let's start with the basics and see what could happen when a vehicle is being put together at the assembly line in a Blockchain-based scenario.

Of course, the issue of Machine Identity predates Blockchain by decades. Transactions of data or value require two parties to identify each other over a network, be they human or machine. To identify themselves, humans have traditionally used usernames and passwords, whereas machines have relied on serial numbers and certificates, and of course also digital keys in recent decades. This offers a playing field for hackers. Forging a machine identity opens access to public and private network resources and makes it difficult for security experts to realize that something is amiss, and even if they do, finding the culprit is often impossible.

HTTPS became the de-facto standard to secure websites a decade ago. It is based on sound security technologies such as SSL and TLS and leverages some of the core cryptography that underpins the Blockchain. However, it is only part of the solution we need for mobility where weak security won't lead to your holiday snaps being made public, but to your life on the road being threatened. But of course vehicles have already had ID numbers for a long time.[7] The Vehicle Identification Number (VIN) is a unique code to identify a vehicle. The VIN is based on two ISO standards, but its composition differs between different regions of the world. The associated paper certificates and also the places where the VIN sits inside a vehicle are far from being tamper-proof and VINs, based on multiple databases, often create a fragmented history of a vehicle without establishing a universal source of truth.

That's the reason why forward-thinking industry associations such as the Mobility Open Blockchain Initiative have started to work on Blockchain-based Vehicle Identity Standards.

[7] A short history of the VIN can be found here: https://www.carvertical.com/blog/what-is-vin-everything-you-wanted-to-know-about-car-identification

> Blockchain can potentially enable new capabilities for mobility. MOBI consortium's initial focus area on digital vehicle identity is one exciting example. A Blockchain-based digital vehicle identity can provide a more accurate record, from manufacturing and ownership to repair, maintenance and mileage history. It can also serve as a foundation for additional Blockchain capabilities such as automotive component supply chain tracking, electric vehicle charging, or even autonomous driving data sharing.
>
> Ashley Lannquist | Project Lead | Blockchain & DLT | World Economic Forum

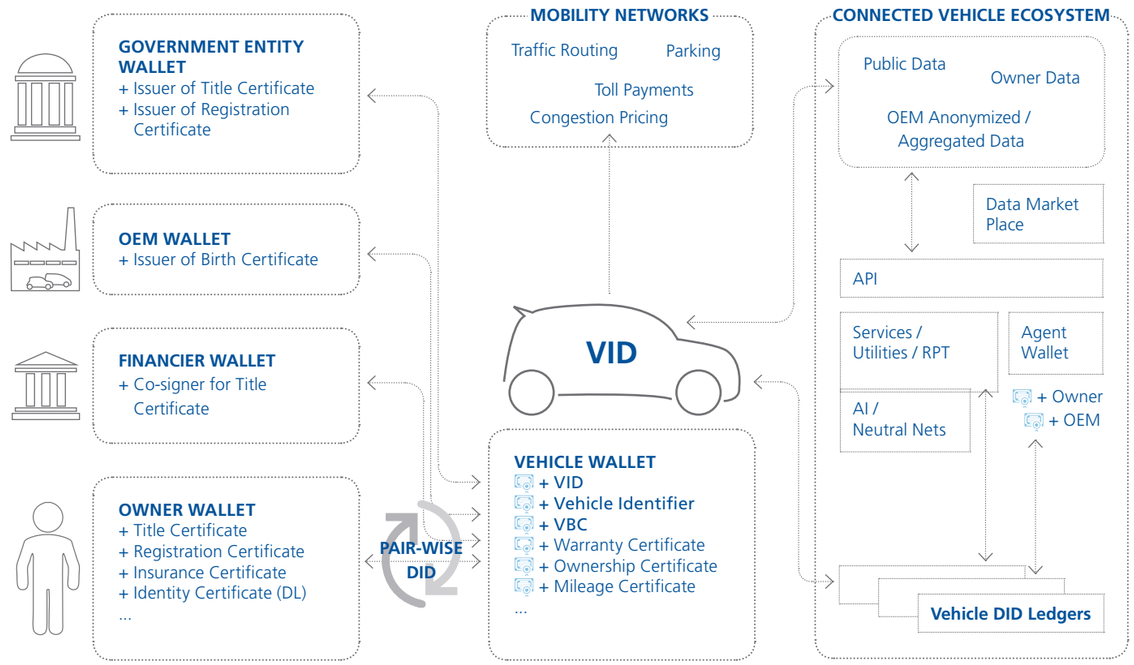


Figure 1: Diagram of the draft version of a first Blockchain-based Vehicle Identity Standard (Source and ©: MOBI / VID Working Group)

The first release of MOBI's VID Working Group's draft standard was published in July 2019 and focuses on the creation of a digital 'birth certificate' for vehicles.[8] This is meant to become the basis for a vehicle's future Digital Twin. MOBI additionally plans standard releases for vehicle's product definition, ownership records and data / event history.

[8] MOBI 2019, Press Release of 17.07.2019: MOBI Announces the first Vehicle Identity (VID) Standard on Blockchain

In general, Blockchain-based identity starts with a record on a public ledger. There is however a question of how to match this with the physical object. This is the famous 'Last Mile' (or 'First Mile') problem that will determine whether these Blockchain data registry processes will stand the most basic test: Can we trust the data that we want to build a new infrastructure and processes on?

Excursus: Hardware Car Wallets as trust anchors

In our opinion (RIDDLE&CODE is also a MOBI member), the best 'anchor' for physically embedding the VIN in the vehicle and 'engraving' it in there in a truly secure way is to root it in a hardware car wallet. This means a typically 17 character-long number from the vehicle's identity number that encodes the make, model and production date, is added into the wallet's keys. Such a Blockchain registry will exist in the future for all vehicles. Dedicated hardware associated with the Blockchain is the most secure solution here, as software, however reliable, can be hacked. This also creates a source of trust to tokenize cars to leverage them as financial assets in a tamper-proof car registry. As the previous paragraph shows, the two most critical features that Blockchain brings to vehicles are a secure identity and the ability to conduct transactions (automated M2M settlements) of data or value in a fully trusted way. These are the two top-level features of the Car Wallet.

> The convergence of rapidly maturing technologies creates a new economy of movement in smart cities characterized by tokenization and ubiquitous pay per use mobility. IoT turns products into services. AI makes the services compelling. Tokenization monetizes the services. And vehicle wallets are the key enabling app tying it all together. A tokenized mobility economy – where asset owners charge a marginal cost for vehicle usage, congestion, carbon footprint, road wear, and pollution – will solve a host of urban problems by linking the economic value of mobility assets to their use and payment. Connected vehicles and digital ledgers will unleash the massive locked capital invested in infrastructure. Transportation assets will become more productive and efficient.
>
> Chris Ballinger | Founder and CEO | MOBI's

Creating the vehicle ID and storing the keys

Underpinning all of this is a sophisticated hardware component concept that is as hacker-resistant as possible with process designs that leave no doors open. Private key storage is critical. It should both be created and stored inside a secure hardware element in the car (crypto chip) and never leave this enclave. Chip manufacturers provision the identity from a certified True Random Number Generator source. This procedure applies to all parties that need to store private keys. All stakeholders can use a similar approach to interact with the system securely.

All mission-critical devices have their own immutable identity on the secure element. Each ID can be linked to the (standardized) vehicle identification number (VIN) and secured via physical fingerprinting, attested on the Blockchain. Integrated chips with Physical Unclonable Functions (PUFs) can also be part of the physical fingerprint ID. We see a much higher degree of security here than with software-only wallet solutions. Embedded Subscriber Identity Modules (eSIM) that equip some vehicle Telematic Control Unit (TCU) are also part of the signed ID.

The pre-provisioned crypto chips built into vehicles, which hold the key pairs, are attested to a ledger via co-/multi-signature. In this signing process, the number of parties involved depends on the use-case. For car identity, the OEM and the manufacturers of related parts with separate IDs can co-sign Blockchain transactions. Co- and multi-signing concepts allow distributed signing of IDs and transactions. The rules with which parties sign or co-sign specific contracts, workflows or processes have to be defined beforehand. A DLT middleware platform can orchestrate these processes. An example of such a software layer is RIDDLE&CODE's middleware. Such platforms offer a distributed web service which creates and verifies the integrity and unique identity of physical objects and creates the ledger transactions.

A Car Wallet to secure V2X Financial and Data Transactions

So let's see now how this might play out in the Blockchain in the M2M era. The vehicle of the future can still have a driver or be autonomous, carrying only passengers. However, in all cases, cars will have more autonomous behavior including payment processes. Some payment use cases already have many solutions, for example, for parking payment (contactless, credit card, apps) where the advantages of DLT may seem less apparent. But they are nevertheless important. Combining the car and the driver or passenger's identities means that personal or financial data need only be entered once, simplifying the multiple app issue. When a driving licence is required, that too will also only ever need to be entered once into the user's Blockchain identity, and personal data will not be exposed, it will just be confirmed as existing and having been verified.[9] For all vehicles, but especially for AVs, there will be cases where settlements happen automatically – within smart-contract-defined parameters – without the driver or passenger needing to know or having to trigger it.

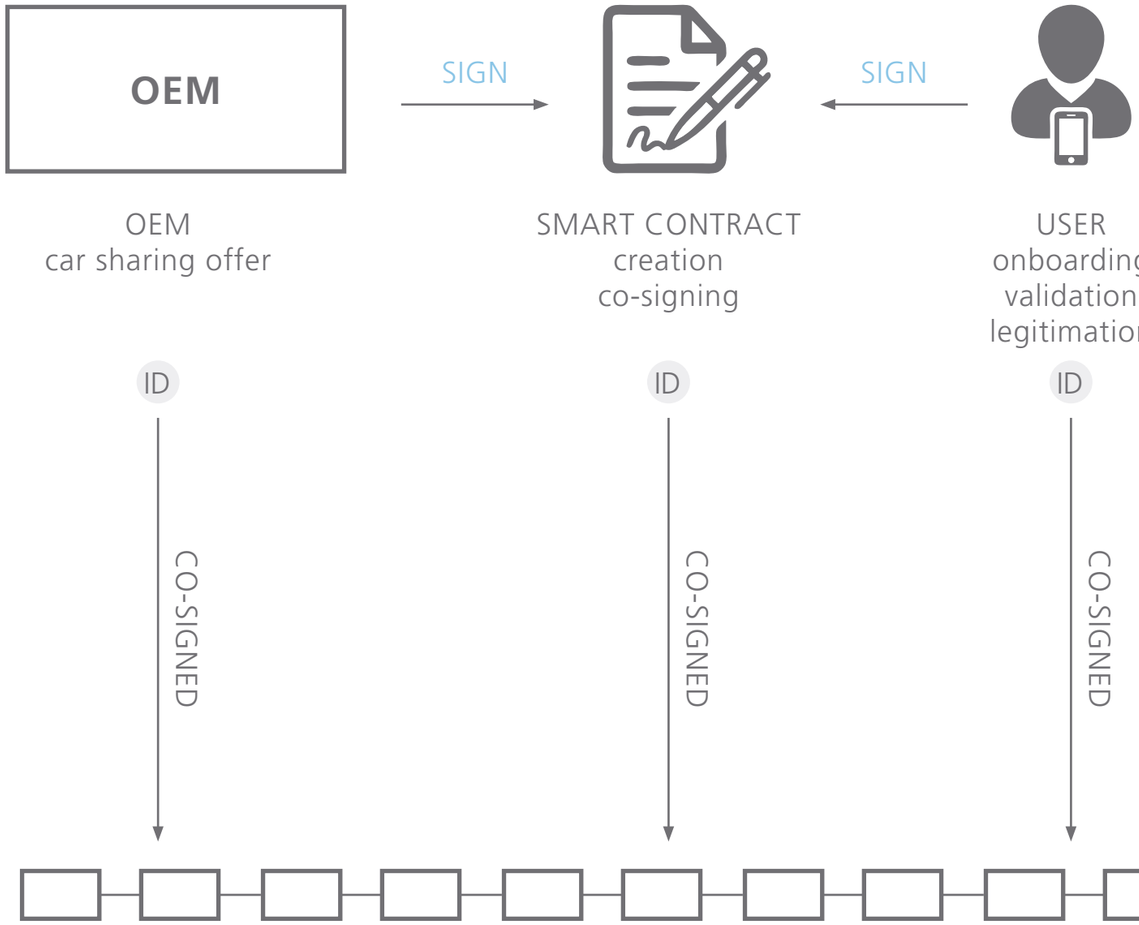
For this to work, the vehicle should have a built-in industry-grade wallet that is fully integrated into the cars' infrastructure and be totally secure. For specific niche business models, such as trucking or rental car fleets, also a stand-alone car wallet form factor can make sense as a retro-fitting device. Only then can the V2V communications be trusted, primarily when road safety may depend on it – for example, if vehicles automatically share road conditions.

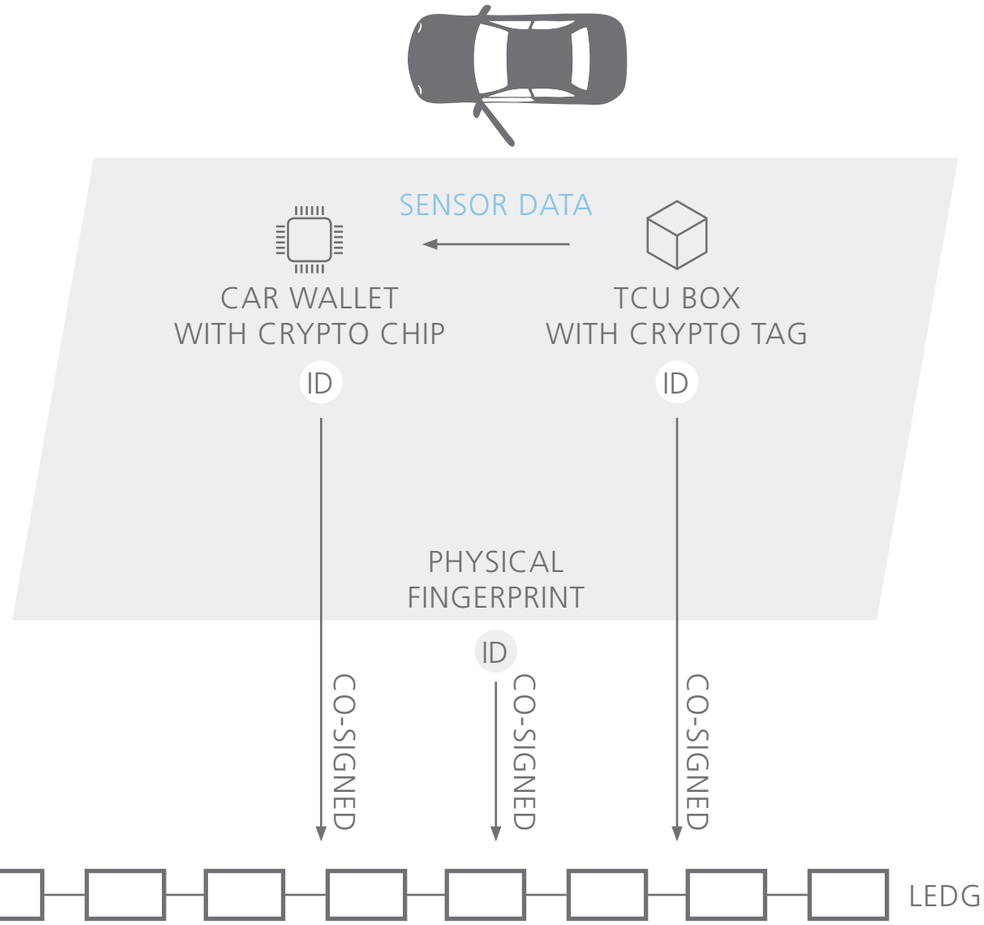
To sum it up, M2M transactions between vehicles and smart (city) infrastructure will contribute to:

- Efficient Vehicle-to-X transactions
- New Business Models based on automated settlement options
- Road safety
- Traffic and route optimization
- Exchange of sensor data (air pollution, temperature, …)
- Toll payments
- Local news and information
- Location-based services and
- Incentivization schemes (for desired behavior or loyalty schemes)

[9] These so-called Zero-Knowledge Proofs are one of the very interesting concepts that the cryptography-based Blockchain ecosystem has to offer. See e.g. L. Schor 2018, On Zero-Knowledge Proof in Blockchains, Medium.com

> In the future, funds will be transferred between humans, enterprises and machines. If in 2025 more than 20bn devices are connected to the internet and a fraction of these devices and vehicles start to take part in money transfers, we will need an entirely new (and probably decentralized) payment infrastructure. We will also need the identities of humans, organisations and machines to also exist as digital twins on Blockchains. This is why Blockchain-based identity management will be critical.
>
> Prof. Dr. Philipp Sandner | Head of the Frankfurt School Blockchain Center





Interacting with authorities

Blockchain promises to do away with many central bodies. However, local authorities that manage car registration processes are here to stay and must have seamless access to information from Car Wallets. Once the vehicle's ID and fingerprint are validated and available on the DLT, the Department of Motor Vehicles (DMV or 'Kraftfahrtbundesamt' in Germany) can check against these transactions and co-sign to officially registering (or revisioning) a vehicle and – in the mid-term – issue related documents. In the long-term, paper documentation will probably become redundant. In the case of the DMV, the secure chip can sit in a signature device that the department uses to verify and sign related transactions. The hardware car wallet described here is Blockchain-agnostic. The final selection of underlying Blockchain platform is not something that needs to be fixed before commercially launching a wallet project. Chapter 4 describes some projects that are DLT agnostic.

Tamper resistance – fraud detection

A Car Wallet also creates a more tamper-proof environment. It can check the vehicle's integrity after an offline period, even if the battery was disconnected. At every start-up, a secure boot mechanism checks the drive-worthiness and availability of all components and IDs that are part of the defined cyber-physical fingerprint. The car then compares its own internal state with the last verified and accepted cyber-physical fingerprint. An age-old issue with vehicles is mileage fraud. Car Wallet can help here. The device securing the vehicle identity is connected to one or several of the vehicle's data bus systems from where it collects telemetric data like mileage or battery levels. This guarantees that the mileage data comes from a trusted source. Periodically such telemetric data gets signed with the vehicle ID and attested on a ledger such as IPDB[10]. We use IPBD as an example ledger here, many others could be suitable. IPDB has the benefit of storing only the hashes of data or transactions on the public ledger, not the data itself which can be kept in a permissioned environment. This means that one can attest mileage levels without making private or sensitive data public. Typically, the public ledger will hold relevant mileage data without providing open access to location data. Other data, like service and maintenance work, can also be linked so that mileage fraud can easily be detected when checking the data history on the ledger.

[10] See www.ipdb.io – The Interplanetary Database, built on BigchainDB technology and governed by the IPDB Foundation, where Riddle&Code is an active participant.

> All future and current mobility services are based on proving the ownership or relevant rights related vehicles. This proof has to be provided by a person or machine upfront, before using the service. That's where the Blockchain-technology comes in. Regulators should allow digital proof of ownership and relevant rights like the right of disposal, sale and use without the need for analogue vehicle documents.
>
> Marcus Olszok | Project Lead | carTRUST

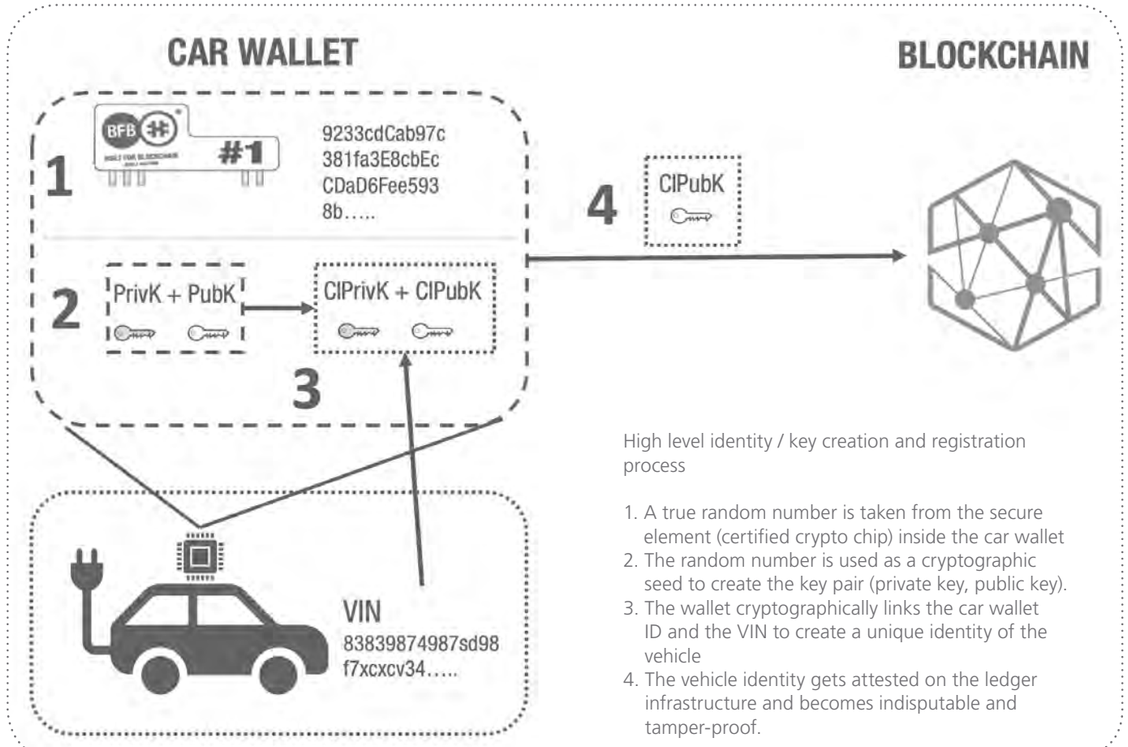


Figure 2: Identity creation and attestation

Privacy and regulatory concerns

Privacy concerns are growing all the time. In a Car Wallet, all sensitive, confidential or private data can remain in closed systems such as ERP databases. These private data sets are hashed, and only the hashes get written into a (potentially) public, permissionless metadata ledger such as IPDB. The hashes allow for the verification of the integrity of underlying non-public data-sets without revealing the data itself. Other regulatory requirements can be met as sensors, and telemetric systems get their own trusted IDs, becoming a trusted source for critical systems. Business logic can be implemented within a smart contract to verify regulatory requirements such as emission levels and initiate appropriate responses and actions.

The jury is still out on whether there will be a DLT platform that the mobility industry will adopt as a de facto-standard[11], perhaps with its dedicated cryptocurrency, or if no dominant DLT will be established internationally. However, that has little impact on the overall promise that Blockchain technology brings to the mobility sector as a whole.

[11] R3 has e.g. managed to establish such an emerging de facto-standard in the financial sector with its Corda platform, that is already widely used and is being adopted by more and more players. One of the reasons for R3's success might be its architectural design, mirroring the enterprise-centric topography of that industry, resulting in a permissioned ledger structure with a hierarchical design.

Enabling ‘Mobility as a Service’ by Consortial Cooperation and Standards

Decentralised DLT technology becomes more secure as the number of participants increases. This benefit is a significant reason why broad and consortial platforms are more likely to be the best way to introduce Blockchain tech for mobility systems. The other main benefits that come to mind are improved usability for mobility customers and the multi-modality of transport systems in general, especially for international and urban travel. In these cases, the efficiency of Blockchain technology to settle inter-party processes in roaming situations can be critical. The usability improvements stem from the fact that in a mobility future that isn’t based on personal ownership of vehicles, it will be better to not have separate DLT platforms and related data-handling processes for different manufacturers.

Industry associations

That’s why mobility providers and especially OEMs have formed several initiatives to jointly discuss these future scenarios and how to harmonise a technical infrastructure. The Mobility Blockchain Initiative MOBI was established in 2018, and several working groups are actively developing standards for digital vehicle identity solutions based on Blockchains, for example. Other industry associations such as the ‘Trusted IOT Alliance’ or BiTA, the Blockchain in Transport Alliance (BiTA) are also covering mobility and have their own, overarching themes in the IoT and Transport & Logistics space.

The mobility Blockchain platform

On an operational level, Daimler Mobility and a group of Blockchain expert startups[12] have initiated the ‘Mobility Blockchain Platform’ in July 2019 and is actively inviting other industry players to join.

The Mobility Blockchain Platform has so far created a Minimum Viable Ecosystem that shows how DLT-based technology coming from different companies can be combined to form an open, industry-grade end-to-end platform. The goal is to demonstrate how backend processes for mobility services of the future can be streamlined with Blockchain technology. Use cases include one-click-rental, fleet management or trucking & logistics. The consortium emphasises the importance of vehicles becoming trusted data sources. RIDDLE&CODE developed a hardware-based, tamper-proof car wallet for the consortium to sign all data that the vehicle sends back to such an industry backend. Discussions are underway as to whether other OEMs such as BMW or Volkswagen will join this platform and to develop its technical solution further. Other relevant players from the automotive industry, such as Bosch, have also declared an interest, as well as insurance companies, banks and other mobility operators. The Mobility Blockchain Initiative has been initially focusing on the definition of industry-grade, future-proof protocols so that DLT involved can enable their solutions with the backend using APIs. This open approach prevents the platform from being bound to any tech supplier. New vendors can be added or brought in as replacements, and if they connect their solutions to the backend APIs and protocols, the whole ecosystem can not only continue to operate seamlessly but also grow and support multiple Blockchains.

This growth will be crucial since several neighbouring industry segments (insurances, regulators or smart city traffic managers) might make their own Blockchain choices. An efficient global system will need to be able to integrate these also. Regardless of whether the system uses permissioned or public Blockchains (the latter being more unlikely in this context), stakeholders will be able to keep the data that is most important to them. Only data that facilitates mobility services needs to be shared. Moreover, no private or personal data will be stored on the platform.

Partners that participate will also be able to keep their most precious data to operate future services, providing them with a high degree of autonomy. 3rd parties that haven’t adopted the governance of such a consortium won’t be able to freely access the data and build business models based on it. If they want to extract data, they would need to make a deal that compensates BOTH the platform consortium members and the users of such a Mobility Blockchain Platform. This shows the political and strategic potential of such joint efforts in the DLT space. In contrast, a handful of now globally dominant ‘startups’ from two decades ago have built successful business models on the open internet from data coming from consumers, the public space and machines that weren’t ‘ringfenced’.

Data sources have never been properly compensated. The overarching goal behind the adoption of Blockchain tech is to create new business models as well as update existing ones with more efficiency. However, these models are, in most cases, financial models, where both tokenisation and new settlement mechanisms come into play. So it can be assumed that financial departments have to collaborate closely with the technical departments within organisations. Both teams will have to learn from each other and influence decisions on the other side. In essence, financial modelling will be a crucial driver to push innovation in the right direction when it comes to selecting and adopting the appropriate DLT solutions.

[12] Blockchain Helix (Frankfurt) for Human digital ID solutions, RIDDLE&CODE (Vienna) for the Hardware Car Wallet, evan. network (Dresden) for the DLT and claim verification platform and 51Nodes (Stuttgart) for Smart Contracts and system integration.

> When properly used, DLTs offer such a paradigm shift as to allow for new types of marketplaces, where it is not only the ledger that is distributed but the entire service stack to. Its potential is to allow for complete decoupling of services, breaking apart silos and opening them up to competition and innovation. From humble anarchistic beginnings, DLTs can become the enablers of free-market economics to increase efficiencies in markets and to foster competition and innovation.
>
> Tal Ater | DAV Network

Enabling Telematics Insurances for Autonomous Vehicles

Privately owned vehicles are at the heart of our current mobility paradigm. Telematics-based insurance products were introduced over 20 years ago. 14% of all new car insurances in the US are telematics-based official statistics report around 100.000 telematics-based insurance contracts in Germany, out of a total of over 116m[13].

[13] Verbraucherschutzministerium 2019, Telematiktarife im Versicherungsbereich

However, this number needs to rise significantly with the growth of connected vehicles; otherwise, it will be challenging to insure self-driving cars. Timestamps and verified vehicle positions are already recorded by law in Germany (§ 63a StVG) if the vehicle's mode changes from manual to semi-autonomous mode. There won't necessarily be eyewitnesses anymore for an accident between self-driving cars. Insurers will be affected by telematics units fraud. Moreover, this is not unlikely, given the fact that 30% of odometer records are estimated to have been tampered with. Clearly, the security in place needs to be improved.

Blockchain technology can play a significant role here while also ensuring data privacy. If Blockchain turns cars into trusted data sources, a car's audit trail can be made available to official bodies via smart contracts. Such a system would be self-certifying in principle, and insurance companies could then offer lower tariffs.

Insurance policies that use telematics today are either based on additional GPS boxes[14], use OBD (On Board Diagnosis) dongles[15] or the TCU itself. Note that for the GPS boxes, built-in SIM cards are not a real challenge for experienced hackers. All form factors have several security issues. That's why a Blockchain technology stack can significantly improve the basis for future car insurances. It can also be decentralised on a hardware level. The drive-worthiness of electric and autonomous vehicles will need to be verified regularly. Integrity checks that send the condition of all of the car's relevant and potentially hazardous components such as the battery, back to a service operator's or insurer's backend can be a prerequisite of future rental processes. So crypto chips attached to these car parts can sign their status independently.

[14] See e.g. UNIQA SafeLine

[15] Odometer and mileage fraud typically happens via OBD2 adapters so only affects a few ECUs

Insurance companies should be ready for 'digital underwriting' in a few years. Then, the DLT-based telematic system itself audits and certifies its status, sending tamper-proof data to secure Blockchains. Insurers, as well as regulators, are then most likely going to either recommend or mandate similar systems. Then we can both audit accidents of AVs and insurers can also incentivise the desired behavior, leading to safer and more efficient traffic. Blockchain-based initiates such as the Mobilio digital currency from Dolphin Labs that is designed to reward safer driving are already being built.

Data Sovereignty for users, corporations and ecosystems

Of course it raises questions if we talk about making it easier for big companies such as insurances to get hold of data sets that are related to our behavior. But let's put this into context and explain the benefits Blockchain-based processes are offering in this context. So let's start with the usual suspects, but keep in mind that most of them were still startups 20 years ago, but were able to build successful services and business models based on an infrastructure that lags far behind Blockchain tech in terms of security options.

GAFA (Google, Apple, Facebook and Amazon) is a small group of large Silicon-Valley-based companies that exploit as much of our data than they can, with often opaque processes. Blockchains, by contrast, allows users to create their own 'Walled Gardens' data pools. So applying Blockchain tech could be seen as a prerequisite to managing privacy without compromising security and authentication. The best AI/data models can be applied to the subset(s) of data of a users choice at a later date. The idea is first to secure the playing field, then decide on who gets to see what and what strategies are used for defence. For traffic management, we need to share data to determine responsibility in case of an accident, for example, but we must also maintain privacy, to avoid the media finding out about a celebrity's trip or simply to protect everyone's right to privacy. DLT will let us avoid the issues that have arisen online.

Policy Layer

Regulation of the online space is still very much "work in progress". This creates unhappy experiences and even election manipulation. However, with mobility, bad or missing regulation can lead to physical injury or even death. Energy use cases in mobility require regulatory clarity and flexibility. Bi-directional use of the grid (as discussed previously, a parked car can "lend" some of its excess energy back to the grid during extreme weather – or two adjacents cars can share energy if one doesn't have enough to complete its ongoing trip) will have to be complemented by P2P trading of energy. The advantage of a decentralized network becomes clear here. Ride-sharing and fractional ownership will also play a role in mobility, and DLTs can add both an efficient backend as well as the incentivisation mechanisms.

Different types of data:

- Data required by the regulator (vehicle ID)
- Obligatory Contractual data (insurance conditions)
- Optional Contractual data (e.g. premium toll booth lane access)
- Personal Data (exchanging via Decentralised IDentities or DID systems)
- Usage data (can be sensitive) for which there will be marketplaces
- Roaming/settlement data between users and mobility service operators as well as for B2B settlements
- Superior engineering combined with good data access and better privacy protection can lead both regulators and consumers to prefer a given AV solution. DLT is the best way to do this.

Driver incentivization via Tokens

Energy-efficient behavior and resource friendliness are another set of objectives that Blockchain can help us reach. Can tokens incentivise desired behaviour in the field of mobility? Are there already concrete use cases that successfully test or use this technology? We will go into these questions in more detail in a moment, but let's start by briefly explaining the differences between tokens and coins.

Even if the conceptual boundaries are somewhat blurred, there are still a few criteria by which the two terms can be distinguished. Crypto coins are usually used as a simple means of storing value or payment and require their own Blockchain – as is the case with Bitcoin, for example. In comparison, the functionality of tokens usually goes beyond the simple means of payment and are operated on a different Blockchain. Like coins, utility tokens have a digital equivalent, but can also give the owner access to a specific system or service. Also, they are used as a means of exchange on the respective platforms. The properties of security tokens, on the other hand, can best be compared with those of traditional stocks. In addition to the participation in the value of the company depending on its performance, the owners may have voting rights and a claim to dividends.

So much for the terms – but how can these tokens be used as an incentive for drivers? Daimler has shown the way with the MobiCoin, which they presented at the Mobile World Congress in 2018 together with the Spanish bank BBVA. By the way, don't let the name confuse you – the MobiCoin is a Blockchain-based token, not a real coin. It was tested with 500 volunteers. The concept was integrated into an existing feature of the Mercedes on-board computer, which shows the drivers how environmentally friendly their driving style is. The driving data of the vehicle is first stored on a Blockchain and then a score is calculated. The more environmentally friendly the driving behaviour, the higher the rating, the better the chart placement in the corresponding app. In addition to the competition idea, drivers are paid in MobiCoins according to individual scores. At the end of the Challenge, these tokens can be exchanged for experiences such as VIP tickets to a DTM race, to the Mercedes Cup Final or to Fashion Week in Berlin. In this way, a gentle driving style should pay off twice over and at the same time, do something good for the environment.

While Daimler's MobiCoin has not produced any public information since 2018 and only had a limited number of participants, a more recent announcement, from May 2019, has been electrifying the automotive industry a lot more: Jaguar Land Rover announced an ambitious plan to connect their future vehicles via a 'Smart Wallet'[16] to IOTA's Tangle and reward drivers with the DLT platform's token. JLR named some data to be explicitly valuable to (potential) ecosystem partners, such as information about the flow of traffic or road and weather conditions. Data is expected to be shared with other drivers or Smart City authorities.[17] At the end of August 2019, the two companies also announced a PoC that allows not only to charge JLR's I-Pace by using the wallet, but also to ensure that only green energy is used. This Proof-of-Concept will take place in Trondheim, Norway, and is also supported by Engie Labs Crigen.[18]

But of course these concepts are not new, Streamr started similar initiatives on a smaller scale with HPE in 2018 and they have also collaborated with Bosch and Riddle&Code to map out similar data marketplace concepts within the 'Trusted IoT Alliance'. That project won an innovation award handed over at Bosch's Connected World conference this May. In addition to all these projects and announcements, there are also considerations and concepts for using these tokens with insurance companies, car rental companies or car-sharing providers. They could evaluate the vehicle data and thus reward quiet and resource-saving drivers with digital assets. This could raise environmental awareness, save costs and enable customers to share in any additional profits of the providers. As we can see, there are many potentially relevant applications where Blockchain tokens can be used to positively influence driving behaviour, ... until autonomous driving takes over. But even then, autonomous vehicles could also be incentivized and paid for fulfilling certain tasks. They would then need a built-in car wallet to be part of an M2M economy.

[16] While JLR's plans are not announced publicly in detail as far as the technology is concerned, it is not unreasonable to imagine a software-based wallet that might be represented by a heads-up display app for the driver, and is connected to the IOTA Tangle via APIs.

[17] A. Smith 2019, Earn as you drive with Jaguar Land Rover and IOTA, blog.iota.org

[18] T. Holman 2019, IOTA partners with Jaguar Land Rover for tracing the car energy with Distributed Ledger Technology, cryptonewsz.com

End to end mobility can be orchestrated, delivered and billed on completely decentralized transaction networks. Blockchain-based ecosystems, such as the Mobility Blockchain Platform, provide fully secure transaction networks reducing the need for intermediaries or aggregators. The peer-to-peer and end to end architecture empowers smaller stakeholders. Each one is fully and digitally identified and can digitally sign business transactions simplifying onboarding and financial processes. Multiple, independent mobility and service providers can combine their solutions into multi-stage, multi-mode and multi-operator offerings. End-users benefit from the service depth and the smoothness of the customer journey, while operators can bundle products which would be beyond their capacity for service delivery and marketing.

Dr. Harry Behrens | Head of Blockchain Factory | Daimler Mobility

04 Mobility Blockchain landscape status quo

> All too often, we have seen companies adopting Blockchain for the sake of having a Blockchain. Unfortunately, the approach of having a solution and looking for a problem to solve with it has led many to use Blockchains as a new type of database. This approach is bound to fail more often than not. Databases have had decades to evolve and improve. They are an excellent solution if you are looking to store, query, and analyze data. Blockchains are not. They are a solution that is wrong for most things... but for the few use cases where Blockchains excel (namely decentralization in trustless environments), they are irreplaceable.
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> Tal Ater | DAV Network CTO

The DLT Use Case dilemma

Since the mobility sector is subject to change, different challenges have arisen within the context of CASE. Therefore, researchers, developers, as well as users, try to address these challenges by using new technologies, such as DLTs. However, in many cases, companies face difficulties in understanding and utilizing DLTs due to its technical complexity and innovative distributed kind of thinking. Therefore, referred to a Bitkom research study (2019)[19], around 88% of companies have struggles in identifying clear business use cases. Nonetheless, to understand the DLT potential and technology itself, companies started working on lots of pilot projects.

[19] Bitkom e.V. 2019, Studie: Blockchain in Deutschland – Einsatz Potential, Herausforderungen

Few projects can tap into the full potential of DLT. Their scopes are often limited due to the lack of qualified expert personnel and resources, legal uncertainties, budget or time. Full autonomous driving is still in R&D (Research and Development). DLT does not seem to offer outstanding benefits for some use cases. Today, they could often be better realized by other or more efficient centralized technologies or infrastructures. A dilemma appears here with so many pilot projects – not just in the mobility sector – arising during DLT discovery phases. The real potential is not visible many commentators are critical. However, use cases do exist where the potential benefits of DLT can be better leveraged. DLT-mobility activities are presented below in ten use case clusters, which are analyzed regarding their meaning and value add for the future.

What's currently going on in the mobility sector?

The most covered use cases in mobility are probably in the area of Supply Chain. With often lagging digitalization, paper documents make supply chain processes more complex, non-transparent and error-prone. Supply Chain optimization is a very active sector. Many companies are working on car part or resources tracking, to prove a part's origin and identify potential counterfeits or avoid child labour. DLT promises them to build trust and transparency between untrusted parties. Whether transparency between all supply chain parties is essential or whether transparency between contract partners is sufficient, is highly discussed amongst experts.

Since DLT's invention with cryptocurrencies and financial transactions, Payments and Finance are the leading applications in mobility. Some companies work on finance scenarios such as cross border finance or promissory note loans. Others work on different payment scenarios like payments between vehicles (e.g. for exchanging information such as free parking lots), payments between vehicle and passenger (e.g. for paying in-car services such as infotainment) or payments between a vehicle and roadside infrastructure (e.g. for paying e-charging or toll stations). In general, companies justify the usage of DLT by automating and securing payment processes as well as making them more time- and cost-efficient. Especially in case of cross-border or business transactions, can simplify the implementation of complex regulations and currency conversions, so that DLT provides an advantage compared to centralized solutions.

Insurance use cases tend to be used to explore DLT for payment as well. Here, companies are working on pay-per-use insurance. Vehicle data such as mileage, driving behaviour or machine maintenance data are transferred to insurance companies automatically. They are then able to trade insurance contracts with calculated prices on a real-time basis. Although similar centralized use cases already exist, DLT seems useful to make the payments and data transfer more efficient and secure. To drive in more eco-friendly and safe way, drivers can be incentivized by money, discounts such as lower insurance rates or cooperation benefits. DLT is not just used for Profiling Rewards, Incentivisation and payments, but also for data security and control. Also, users can achieve more transparency in their data flow and better data privacy. However, people are often willing to share their data freely, as long as they are benefitting, as can be seen with fitness tracking apps, for example. So this might not be the most plausible use for DLT.

Using DLT in the sharing economy is more meaningful due to the participation of different and untrusted, often competing entities, which all might benefit from cooperating. Companies already share information for renting and leasing with Know-your-customer (KYC). If they share driving profiles such as driving scores, for example, DLT can enable trusted score-based pricing models without having a central intermediary that needs to be paid. The combination of incentives and KYC adds value to car manufacturer and customer.

The sharing economy lets companies provide Secure Access on a DLT-basis to non-owned cars without a physical key. DLT delivers data security and control. The access itself can be accomplished by public-private-key encryption. In combination with payments, a distributed ledger and autonomous driving make DLT seem

Where are we with DLT solutions in the mobility sector?

more useful. Transactions of a self-driving car or a self-owned financial identity are recorded safely. Due to the e-mobility trend, an increased energy offer is required, but charging infrastructures are limited. Companies are working on Energy distribution use cases, where energy can be traded on a peer-to-peer basis. Here, DLT smart contracts are used for automation and control purposes with intelligent grids. Energy use cases often come with payment and supply chain through the proof of origin of renewable energy resources. DLT is mostly used because it reduces microtransaction costs. Vehicles create masses of data, which can be used for control or fraud detection, especially on the used-vehicle and aftersales markets. Companies work here on trustful digital representations via DLT, so-called Digital Twins. Every third used-vehicle in Germany has a manipulated mileage or/and service record. Storing this data on a distributed ledger provides an immutable and single source of truth and transparency, which would not be possible with a central authority. Controlling any vehicle data and data histories is valuable, but with autonomous vehicles, the value increases significantly.

A future sharing economy with Decentralized Services can improve driver safety as well as convenience, for example with real-time traffic or road condition warning or with a Mobility-as-a-Service platform where users can access the services of different providers with one log-in. A Data Marketplace can be used to improve and boost these services. It can also help car manufacturers to monetize their data and differentiate their brand. Here, companies use DLT because of its single source of truth, trust, data security, transparency and its efficiency boost. A centrally based system would not be able to handle such a complex multi-party system, because companies would be unwilling to share their data.

Data exchange and trade can also be used for communication between vehicles or vehicles and infrastructure. This is called V2X communication. Vehicles must securely communicate their routes with each other to enable autonomous driving such as truck platooning. The data should be confidential and unalterable so that failures or accidents are avoided. Challenges regarding the authentication of the vehicle and the confidentiality of the transferred information (see section 2) can be overcome by DLT. Indeed, it is an unchangeable source of truth and provides transparency about communication. Spoofing, modification, node imitation and sybil attacks can be detected or made impossible. Updating vehicle software or driver assistance systems OTA benefits from DLTs intrinsic security and bullet-proof identities. A central solution would not make sense due to the number and variety of vehicles, infrastructure providers, customers and automobile manufacturers involved.

> DLT can be used in mobility in many application areas with exponential growth. First, Blockchain and DLT-based payment methods are used to enable IoT, and thus vehicles, to pay independently and become economically autonomous to a certain degree. Multimodal mobility concepts for travel by various means of transport and providers, as well as in logistics, follow. Thanks to networked ecosystems, DLT enables products and services to be built on others without the need to establish a traditional, time-consuming and labour-intensive business relationship. In the long run, DLT can integrate autonomous vehicles into these networks and physical infrastructure.
>
> Claudio Weck | Blockchain Expert | Porsche Digital

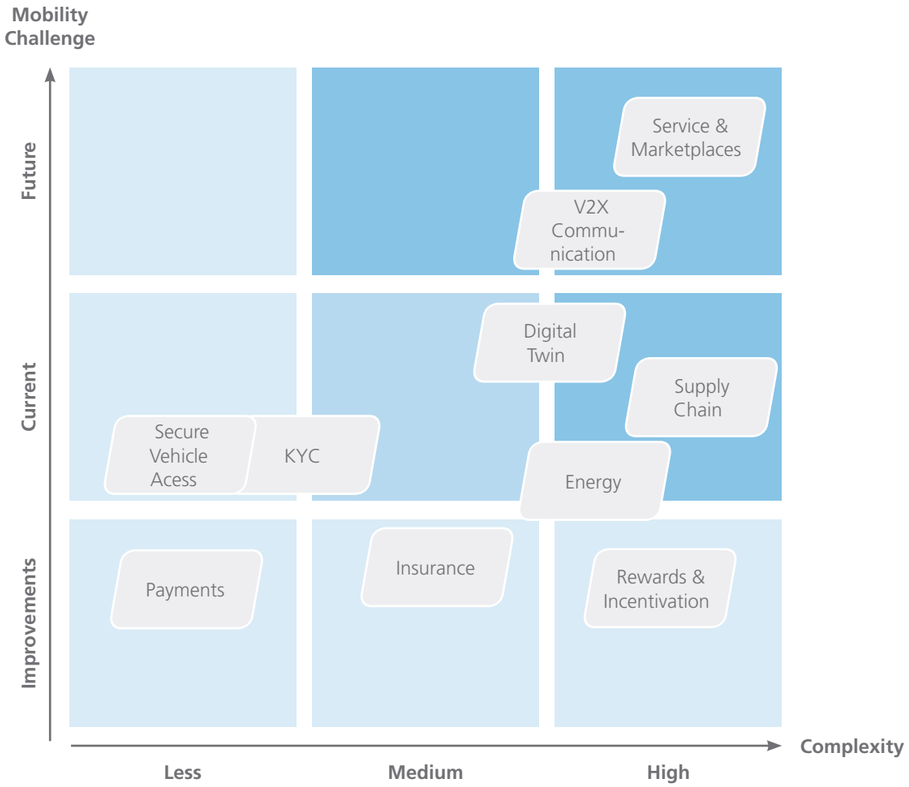

Figure 3: The actual DLT-Mobility Landscape
The use cases in the left-bottom corner describe "low-hanging-fruit", on which companies are currently working on in stand-alone learning projects. In contrast to that, the use cases in the right-top corner describe the most complex use cases, where the usage of DLT can solve mobility challenges and boost the development of connectivity, autonomous, shared and electric (CASE) use cases.

Solving Existing Mobility Challenges

As already mentioned, the relevance of DLT is not always apparent. For example, online payments are today possible via PayPal or ApplePay. Black boxes exist for data transfer to insurance providers. Shared vehicles can already be opened without a key (e.g. Car2Go, Drive Now). DLT does not solve any known mobility challenges here.

Even more complex cases with a broader spectrum of participants such as supply chains and energy distribution processes can be digitizable in other ways. Standard software that follows predefined rules or machine learning algorithms to create rules can be used. But because rules can be manipulated and machine learning algorithms can be retrained, smart contracts on a distributed ledger make sense as they are resistant to manipulation. DLT could solve the security and complexity challenges here. In addition, DLTs can overcome the vehicles' challenges enabling secure and trustworthy automated data transactions without human interaction or ownership, by becoming their own vehicle identity. This is possible using secure car wallets (see section 2 "car wallet").

DLTs also enable unique identities because they represent a single source of truth that avoids identity duplication. All transactions are stored unalterable and traceable so that data cannot be manipulated or imitated. Payments, software or services cannot be duplicated. The vehicle identity is not an application area itself, but a strong basis for solving the mobility challenges of a trustful (autonomous) vehicle data exchange. It enables digital twins, V2X communication, services and perhaps the most complex use case due to the number of untrusted participants, data marketplaces. Unique identities make the payment, insurance, profiling, KYC and secure access use cases more meaningful. DLT also ensures efficiency and security. Users may not yet see the benefits of DLT today. But when we think about the future with autonomous vehicles, we cannot avoid the need for unique vehicle identities and non-manipulable rules within these applications. Combining today's standalone DLT mobility application cases into a fully autonomous structure will create value.

A detailed view of five Use Cases

In the following paragraphs we present five running Blockchain projects, which give a good snapshot of the current technological and economic status of Blockchain projects in the mobility sector.

1. High Voltage Battery Tracking

With electrification, vehicles are subject to change. Simplified powertrains and high-voltage batteries replace sophisticated and mechanical units of combustion. The high-voltage battery (HVB) is becoming the core electric vehicles. With around two-thirds of the vehicle's cost, HVBs are the most expensive part of a car. Experts expect the HVB to become the most attractive vehicle part for counterfeiting. An HVB is also the most sensitive part of a vehicle. Incorrect charging cycles (e.g. less than 30% or more than 90%) decrease its energy capacity. Total discharging and recharging can damage the modules and therefore increase the risk of explosions and fire.

Neither the manufacturer nor the OEM or logistics company wants to risk physical damage to their business and image. To improve safety and offer warranties, they want a secure cross-company solution that provides battery charging lifecycle transparency over the supply chain. Other stakeholders might also be interested in using the HVB data. Insurance companies and end-users, whether car owners or drivers, can use data for risk calculation or resale, for example. There is a need here for a secure proof of origin and authenticity.

These multi-party requirements create a market for the tracking of relevant HVB lifecycle and charging information over the supply chain. A distributed ledger such as Blockchain can benefit the supply chain participants within a Blockchain consortium. Thanks to redundancy and encryption, non-trusted parties can exchange trusted immutable data, so that the supply chain participants can retrace the charging and HVB lifecycle information to meet their security needs. Together with a South-German car manufacturer, MHP developed a DLT-based tracking solution for HVB data. The current implementation uses a private permissioned Hyperledger Fabric network to guarantee the privacy of HVB data within the supply chain. Non-personal data such as the HVB serial number, product number or charging location are stored on ecosystem ledgers. Because this information already exists in company-based central enterprise-warehouse-management systems (such as the SAP EWM), the primary data source can be linked to a distributed Blockchain network. Non-personal HVB information can be made available and relevant data immutably stored with a unique HVB serial number. Whenever an action is written to the SAP EMW system, it triggers a Blockchain transaction to a node, which is located within the same SAP cloud. Data is forwarded to the Blockchain network securely, stored immutably.

However, the data of the company-based central data source could already be manipulated before being stored in the Blockchain. Blockchain technology does not secure the data source or data transfer to the ledger. Distributed data storage, together with a distributed data source, might solve this security issue: Future HVBs should transfer their data directly from their electronic control unit (ECU) to the Blockchain. The effort to manipulate such a system would be higher, as each battery needs to be hacked instead of just one central company-based data storage.

2. carTRUST the Vehicle Registration Ledger

As soon as we look at the future of mobility, we quickly encounter processes around the vehicle itself. Many mobility processes are already being digitized, with many topics having remained unchanged for years. One example of such a stable process is vehicle ownership. The following chapter presents carTRUST, a solution from the Kroschke Group – a German market leader for vehicle registration services – for digitizing this process.

The Use Case describes the process optimization for vehicle ownership by combining the advantages of Blockchain technology with the existing functions of the typical vehicle register. The basic idea of carTRUST is to simplify and accelerate the daily approval processes with which authorities, companies and citizens are in contact. carTRUST sees itself as a driver of digitization in the field of vehicle administration and vehicle registration. Specifically, the decentralized platform is a link between all parties involved in the management of vehicle ownership. In contrast to the current analogue ownership management, the participants can manage ownership of their vehicles digitally on carTRUST's Blockchain-based platform.

carTRUST focuses on processes around car registration and identifies the lack of digitization as a problem factor. Many documents in the registration system and in the methods of vehicle sales are currently analogue. This leads to high personnel and material costs for authorities and time expenditure for citizens. carTRUST sees the optimization potential in a change from an analogue to a digital alternative. Through the use of Blockchain technology, property information is protected against attacks and manipulation. Also, the decentralized nature of a Blockchain provides a fail-safe and fast network. The implementation of Smart Contracts enables the platform to act automatically. According to carTRUST, 80% of all car registrations can be fully automated. This shows the optimization potential of processes in public administration.

carTRUST also simplifies the citizen's lives as the platform enables immediate registration, change and deregistration of vehicles without analogue documents. The use of apps, platforms and interfaces enables these activities to be carried out from home or the street, without needing endless trips to the authorities.

Manufacturers, citizens, service providers, insurance companies, banks, dealers and registries are all in contact on the platform. The current implementation of the use case at carTRUST is in a pilot phase. Together with public offices, car dealerships and fleet companies in Germany, carTRUST is working on the implementation of a digital vehicle registration service without having to visit a public office or manage analogue vehicle documents.

carTRUST's vision describes a consortium-based, public-permissioned Blockchain[20] with which each stakeholder provides nodes in the network. In the case of the used car market, data collection requires a trusted body to certify the data and then write it to the ledger. This is initially the Kroschke Group, but in the future, there will be more independently verified identity[21]. For the new car market, the trusted authority of the retailer guarantees this information. Only the property rights are held in the Blockchain. Personal GDPR-related data are stored outside the chain. Because the project is currently at an early stage, we have no information about future implementation. Nevertheless, the demand for the management of ownership and rights (usage rights, sales rights, etc.) of vehicles is high. Also, the idea, the technology, the fact that the use case addresses a pressing real-world problem and has excellent optimization potential for existing tasks is an indicator of future implementation.

[20] Based on even.network

[21] Evan 2019, How it works: Verification Management, evan-network.github.io

3. Gapless, a Collector's Marketplace

The world of mobility is changing. Autonomous driving is on the horizon, and there is an increasing desire for vehicles with character, to tell stories from past days and to convey the real driving experience. Collector vehicles such as classic cars and other premium vehicles are used both for joyrides and for investments. However, the documentation of the vehicle history is often still analogue and thus particularly prone to fraud and forgery. It is difficult to exchange information with interested parties, especially with more extensive vehicle collections.

The Gapless platform provides a digital marketplace for managed services so car owners can now enjoy their "toys" even more. Analogue processes, paperwork and a lack of transparency and convenience typically affect the owner's experience – Gapless has developed a highly secure platform to address these issues. Events such as vehicle inspections or repairs can be tracked in the complete history and even certified to obtain third-party confirmation in the event of a sale. Beyond the maintenance of collections, Gapless also offers dedicated services such as insurance, certificate of authenticity and expert opinions. Gapless maps physical classic and premium cars to digital assets, preserving the properties that make collectables unique, such as rarity, scarcity and intrinsic value. So far, no one has tried large-scale digitization of illiquid collectables because there was not the right technology to implement the ideas.

The Blockchain has changed this, as it can overcome several obstacles, such as the representation of scarcity online. Most digital media such as music or video are relatively easy to reproduce – no matter how robust the copy protection is. With Blockchain technology, it is possible to preserve these specific characteristics of collectables and remain cryptographically unique. Furthermore, it enables the existence of property rights in the digital world through verifiable and traceable ownership of collection and premium vehicles. This not only prevents counterfeiting but also facilitates the seamless peer-to-peer transfer of assets between users on the transparent platform.

Gapless takes the privacy of personal data very seriously, using several methods to ensure compliance with GDPR guidelines. One of them is to combine personally identifiable information (PII) with non-PII data that is not stored directly on the Blockchain. Gapless stores this type of data in an encrypted InterPlan-

etary File System (IPFS) and not on the Blockchain. Only references to entries in IPFS are stored in the Blockchain. Customers can access their own data with their private key. In this way, the data owner retains control while benefiting from the strength of the Blockchain. Future developments in this technology could also help to extend security and implementation capabilities beyond this level.

4. XRide for Simpler use of eScooters

XRide is a Blockchain-based Mobility Consortium around electrical Scooter Rentals & Charging. Mobility Solutions built on Blockchain-based backends share many of the same building blocks and features. This is visible in "XRide", one of the most recent consortial projects in the space initiated by Deutsche Telekom's Innovation Labs' Blockchain team and the collaborating companies, including Bundesdruckerei, IBM, Jolocom, RIDDLE&CODE, Giesecke+Devrient Mobile Security, Ubirch and the two fleet operators Simple Mobility and Telekom Mobility Solutions. The project was publicly announced mid-September in Bonn and will cover Bonn and Berlin first with electrical scooter test fleets. XRide orchestrates a Blockchain-based vehicle rental and charging process. It is designed for real business environments using tamper-proof vehicle IDs as well as digital human ID solutions that are all connected to a Blockchain-as-a-service platform.

Deutsche Telekom has developed such a Blockchain operating stack called 'stax'. The operator plans to enable corporations to build apps and business processes on top of it – without the need to develop detailed Blockchain know-how internally. Additionally, stax promises to allow for changes to the underlying choice of Blockchain technology without having to touch the code itself. XRide is an open, decentralized E-Mobility ecosystem. Its major functionalities include payment, data verification, storage and identity management – both for humans and the scooter itself, and additionally charging of the vehicles – all managed by Blockchain technology.

Existing mobility backend solutions already enable scooter rentals around the world today, but they obviously don't leverage the benefits of DLT solutions. Some of XRide's features are new and underline Blockchain's potential. They include managing swappable batteries at recharging stations and the highly secure vehicle identity, created with an embedded scooter wallet that uses a crypto chip module. Going forward, consortial mobility projects like XRide will help to establish and model a corporation's contribution and business aspirations in the DLT and IoT space. These can include vehicle connectivity, charging solutions or settling of payments and invoices or integration projects at a larger scale between different technical ecosystems and industries. Telecom operators may initially target SIM card-based connectivity solutions, but there are other promising avenues to explore. These include security and identity management, and possibly data marketplace solutions and payment services. XRide already incorporates microtransactions, a significant building block for future, multi-modal solutions. Since this will require settlement and roaming data exchange of value between various parties.

Traffic management infrastructure providers are entering the stage and are also interested in the nascent industry consortiums. Siemens is active in e.g. roadside units while Bosch is focused on different aspects of 'Economy of Everything'. Others such as Kapsch have not yet set sail. It is, however, clear that traffic management, toll solutions and smart city systems will have to integrate with mobility solutions. This is where big corporations such as Deutsche Telekom and T-Systems also see potential value. They are looking to manage future integration efforts by (partially) automating them within open and interoperable ecosystems. So XRide might be a frontrunner in many ways.

"Xride is a mobility showcase project for T-Labs and all of its partners. It's important to have tangible ways to show how Blockchain powers shared infrastructure for ecosystems – which we have accomplished. We look forward to evolving this into production soon!" said John Calian, Head of T-Labs at Deutsche Telekom Innovation Laboratories.

5. Data Monetization Platform

Swarm intelligence is regarded as one of the most significant prerequisites for autonomous driving. When vehicles exchange data such as real-time traffic or road conditioning data, their routes become more efficient and their driving safer. It still promotes driver comfort today by enabling new services such as real-time parking or high-precision weather information. The principle is the more data a vehicle or service provider can use, the more efficient the services! But how do you get this amount of data? Competitors such as car manufacturers and service providers are generally unwilling to share. More and more users also tend to protect their data instead of sharing it. An incentive through data monetization could break open the silos and allow several competitors and users to collaborate[22].

To overcome the rejection of data exchange, HPE and Continental developed a DLT-based platform for peer-to-peer data trading. It creates added value for all parties by exchanging data for money or benefits (e.g. real-time traffic services). The data is not publicly stored in a distributed ledger or processed on the network to protect the privacy of the parties. In contrast: It is stored off-chain on the parties' central servers, ensuring data sovereignty.[22] The data transfer is fully end-to-end encrypted and the data can only be used if the data consumer has purchased his respective key.[23] Only metadata (e.g. data specifications or payment details) is stored and shared in a distributed ledger. The data exchange platform's first prototype was based on the Ethereum stack. It enables user authorization, payments and rewards transfers. Ethereum's Smart Contracts are used to make the contract and payment processes more efficient and secure, overcoming the barriers to the transfer of vehicle data.[23] [24] Ethereum is not the only possible solution. It was chosen due to simplification and existing acceptance. In production, the platform will be DLT-agnostic.

However, the platform architecture is not fully distributed. It contains a central platform customer interface between the DLT and the automobile manufacturers, service providers and vehicle owners. It supports participating companies in integrating the data into their backend systems and existing services. Continental and HPE charge license fees to use this interface. Participating companies also pay transaction fees, while vehicle owners pay with their data in exchange for e.g. free driver assistance services, vouchers, direct payments or nothing. It is up to the automobile manufacturer or fleet operator how to incentivise owners,[24] as this isn't part of the platform itself. In addition to this centralised part and the collection of transaction fees, Continental and HPE are following the principle of traditional platforms such as Otonomo. They operate the platform in such a way that "no consortium" (Reichenbach – HPE Transformation Consultant) is required to operate the Data Monetization platform[24]. Ultimately, DLT increases the performance of the platform for user authorisation, payment and contract purposes, but isn't used for the platform's operation. Extending the use of DLT could bring even more benefits to stakeholders. If DLT takes over all accounting tasks, the total transaction costs could be reduced and distributed to all participants[24]. However, from a business and political perspective, a completely decentralized operation and governance of such platforms is one of the greatest challenges. Not only is today's lack of a sharing and cooperative mindset curbing the feasibility of a fully distributed platform, but the legislator with its cartel law is also putting obstacles in the way of business. No best practice approach exists yet to make sure that a completely distributed platform will be accepted.

> Distributed Ledger Technologies will be of highest relevance for future mobility services because of their capability to de facto notarize critical incidents in the age of autonomous road traffic. Also, manoeuvring Smart Cities in the future with AVs will only be feasible with these technologies. Additionally, the option to pay digitally and in a secure way – without needing to know or trust the other 'party' in IoT contexts will become essential and will only be hard to achieve without the use of DLT.
>
> Peter Busch | Product Owner DLT Mobility | Robert Bosch GmbH

[22] Continental AG 2019, Press Release of 26.02.2019: Continental and Hewlett Packard Enterprise Launch Blockchain-Based Data Monetization Platform

[23] Continental AG 2019, Internal Source

[24] G. Nott 2019, Your car's a weather station on wheels with new HPE, Continental blockchain platform, computerworld.com.au

05

Planning the Future – DLT Challenges and points for discussion

> The technical challenges, such as appropriate transaction speeds and consensus algorithms, are currently being solved. However, a few more quarters are still needed to complete and sufficiently test solutions. In payment transactions, additional time is needed to implement legal regulations. In Berlin, the government and the Ministry for Mobility and Digital Infrastructure are currently working on this. However, it is more important to develop decentralized business models and exploit their advantages.
>
> Claudio Weck | Blockchain Expert | Porsche Digital

The Blockchain community is discussing the future of Blockchain. Will people give up trusted intermediaries and follow decentralization? What will future business models look like? Will the government support collaborative innovation at scale? Are we able to integrate innovations in traditionally less agile industries such as the automotive one? We'll also take a quick look at Blockchain's compatibility with GDPR.

Centralization vs. Decentralization

There are numerous areas where future mobility services might generate new revenue, which we have covered previously. From a strategic business perspective, DLT-based projects all share a critical characteristic that must be understood for business planning.

Software development has been showing the way with the open-source movement that is now already decades old. IT is part of the move from centralization to decentralization and has taught, even the largest corporations, that some level of sharing is beneficial. Rewriting a modern operating system has, for example, become a herculean task. Even a company like Amazon chose to reuse AOSP, itself based on Linux, to develop its own Fire platform.

Peer-review and access to many more test cases are vital benefits of decentralized open source development. A significant drawback can appear where time-to-market is essential as an external contributor that is on the project's critical path may slow down the whole project. Blockchain projects are usually based on open-source, and they are all about industry collaboration. So from a business model perspective, any returns on investment must be measured collectively. When the number of paper documents required in a product's lifecycle is reduced by a factor of ten, the whole ecosystem benefits. In our automotive case, as we have explained above, the investment required for an industry-wide DLT backend will be recouped over several years. Early adopters may have to pay more upfront than later arrivals. As new stakeholders join, they will be paying mainly marginal costs, part of which will be used to reimburse early investors.

Governance

Governance is a critical component of any decentralised system. The open software movement has given us a few decades of experience. Governance itself must be transparent to be trusted, which is prerequisite for any outcome, such as a transaction recorded on a ledger, to be trusted. Blockchain is a new and evolving technology, so a primary role for the governance structures is to ensure that it can evolve. Stakeholders will change their requirements over time as experience shows them where they can get more value. The rules by which consensus is reached are particularly sensitive. Of the many angles from which to look at the problem, the governance body itself must be set up with rules and policies agreed on then the operational rules to run the system must be agreed on. In the Blockchain environment, the former is referred to as "off-chain" and the latter is mainly embodied by "on-chain" rules. A self-sovereign network needs authorities, such as government or other trusted sources, to issue initial credentials. Blockchain protocols can then guarantee their integrity with on-chain governance mechanisms.

Typically in the Blockchain space, foundations are set up. A range of diverse institutions and firms from different value chain segments are in charge of the platform's governance. But none of them – by design – can exert dominant influence, and ownership is decentralised. Foundation members can sign credentials using their (authority) nodes using standards such as DID (Decentralised IDentities). Ideally, these nodes also incorporate digital wallet functionality to manage keys securely.

But this has only been a glimpse of the technically rooted governance of Blockchain systems. At least of equal importance is the governance that is fixed when consortial groups of an industry or neighbouring industries agree to collaborate based on Blockchain technology.

What do we need to talk about?

> After Dieselgate and with the growing importance of data, trust is becoming the central pillar of the emerging, more decentralized mobility sector.
>
> Alexander Koppel | CEO | RIDDLE&CODE

DLT and GDPR

The European General Data Protection Regulation (GDPR) was introduced in May 2018. Let's look at the compliance of DLT and GDPR. Indeed, 72% of German cross-industry companies see legal uncertainties as one of the top challenges for DLT applications.[25]

GDPR is only directly relevant for DLT use cases when personal data is processed. The problem that comes to mind first is the right to erasure, which enables people to erase all their personal data from a platform. This contradicts the DLT principle of immutable data history, so one needs to find a solution to make GDPR and DLT compliant.

[25] Bitkom e.V. 2019, Studie: Blockchain in Deutschland – Einsatz Potential, Herausforderungen

[26] C. Kuss/ C. Bader/ K. Preikschat 2018, Blockchain DSGVO-konform betreiben, cio.de

Whether a specific piece of information is personal data or not, depends on the possibility to retrace it back to a real person – directly or indirectly with additional data sources. Personal data can be a name or phone number, but also the vehicle registration document or VIN. Encrypting data and storing just the corresponding hashes on the distributed ledger does not necessarily solve the issue because the personal data becomes pseudonymized rather than anonymized. So whether this is sufficient to achieve GDPR compliance or not, has to be analyzed at one's own discretion by considering the cost, time and technical expertise required for hash hacking. The legal status and protection needs of the person concerned have to also be considered.[26]

Storing personal data "salted" with random numbers and hashing it afterwards, can be GDPR compliant because hacking it would then be too costly. A solution can come from storing personal data off-chain, in an encrypted database, and storing just a reference to it on the distributed ledger. Then, if the database entry is deleted, the reference has no meaning anymore. In the end, designing a GDPR compliant architecture is a case-by-case issue as best practices do not yet exist. This issues still holds back some DLT projects.

Product development cycles and Blockchain

Planning the introduction of new technologies in an industry with relatively long product planning cycles complicates innovation. All the more when we consider adding hardware to such an elaborate piece of technology such as a car. It would take three to four years to embed a hardware-based car wallet into a TCU box. And in a market where large corporations' strategic planning takes place over at least five years, the implications of adding a car wallet can be undervalued. This is one of the reasons why start-ups are being successful in introducing the technology to enable trustless transactions. Indeed, quick adoption of DLT solutions is possible, even at the hardware level. Retrofitting can be a solution to connect legacy vehicles to DLT solutions.

A vehicle fleet that plans to source from more than one vendor would benefit from such a retrofit. Devices that are delivered and then connect over-the-top can also enable Blockchain connectivity. In an adjacent market segment, German Autolabs have successfully launched an 'independent' aftermarket device to bring voice assistant features to drivers without a navigation system[27].

[27] See www.germanautolabs.com/chris

But if we talk about asset tokenization and its adoption across all industries, it is clear that the financial industry is leading. The automotive sector has a double disadvantage. Use cases and business models are less apparent and technical integration can be harder than in the financial sector, for example. We are already seeing new software entrants from the Blockchain technology industry trying to disrupt OEMs leadership. These new entrants are attracted to a shared and electric vehicle future, where usage data creates more unique selling points than the power of OEM-dominated components such as the combustion engine.

Future business models

Thinking about the future of mobility, we need to change our perspective from being in the driver's seat to become a passenger. Automatic, or even autonomous settlement will make users' lives easier when they use self-driving cars. Such automation will also enable more of the business models we are already seeing with, for example, automated settlements for mobility services or electric scooters all over our cities.

Additionally, location-based services will play a stronger role, as will entertainment and advertising options for passengers. Since we are, for better or for worse, in the age of data and analytics, we expect truly disruptive new business models to become possible with the monetisation of mobility data. But these new models also carry the risk of being offered 'over the top'. There would then be no guarantee for OEMs or other mobility service incumbents such as railroad operators to benefit automatically from these new revenue streams. Airbnb, Uber and Netflix all made money without being the owner of the underlying infrastructure. OEMs will have to be agile as an army of startups is waiting in the wings to offer data-driven 'over the top' platform-based business models. One of the most essential tools to master this challenge might be the use of DLT technology. As discussed previously in this chapter, a significant contribution of DLT is to create trust, and in our case, trusted data sources. Regulatory pressure or the future of car insurances might incentivise OEMs to embrace Blockchain. DLT stacks can also help OEMs and mobility services operators safeguard their R&D investments and better leverage car fleets.
Blockchain technology will help them to not only own the hardware but also to control the data that these vehicles generate. Sharing data in a controlled, secure and trustworthy way with other partners will be critical. By forwarding relevant cryptographically secured data to a highly secure data repository aka Blockchain, OEMs cannot not only protect data flow from hackers but also against competitors with their own powerful data harvesting platforms. So the ingredients for future business models are:

- Mastery of data usage,
- Protection of private data,
- Enablement of cheap, efficient and secure transfers between:
  - service users,
  - the platform operators backend,
  - machines themselves.

The platform and associated tools can remain in the hands and fully controlled by a service operator or consortium. Members can collaborate with other players in the space to model incentivization schemes, tokenization projects or fractional ownership. However, the most successful companies will probably have to adopt a 360° view and truly understand how to benefit from all the dimensions that DLT is opening up. Since most of these models are strategic, advanced financial thinking is needed at the core, and the launch of new services will become more interdisciplinary than ever. There will be openings for non-obvious adjacent models, so let's just pick two to three examples as an outlook:

Road safety can be a matter of life and death, so the integrity of data is crucial. Only when we have enough trust in it can we consider, for example, sharing sensor data from one vehicle to another to initiate early braking. We already have endless numbers of cars and even fleets that regularly patrol our streets so road condition data could be crowdsourced. Dedicated vehicles could carry special equipment, such as buses in cities, or even trucks that are collecting the waste throughout a town regularly. Swarm intelligence can find smarter routes for Robo-taxis, for example, and the monetisation opportunities here are boundless. Small streets without businesses might be able to offer a premium if cars don't drive through them during the night. In the same way, a city could incentivise precise parking or driving behaviours or organise last-mile delivery services.

Blockchain technology can be a major enabler for jointly operated ecosystems. This is relatively new for established companies in the automotive sector but of gaining importance – especially in the field of multimodal mobility. Blockchain applications will replace existing solutions to increase efficiency internally. They are also most likely to replace established business models and business relationships across company borders. Multiple economic and political challenges accompany this novelty. Based on our experience from concept studies and pilots, these prove to be a bigger hurdle than the technology itself.

Julius Vomhof | Program Management Digitalization | Schäffler

06
Summary

> Libra, Binance and the digital version of the Chinese currency are all projects that will change the financial sector and potentially turn it upside down internationally. Whitepapers and PoCs here and there are of course helpful not be sufficient. We now need relevant budgets. Startups and tech companies have already developed the technological base and proven the plausibility of Blockchain technology. States, governmental departments, industrial corporations, banks, investors and universities alike should invest now. It is an investment in startups, IT development and integration with legacy processes and systems that are of the highest importance. Today's opportunities are clear for corporations. The ones who are not going to consider this topic today will be facing severe problems in the future.
>
> Prof. Dr Philipp Sandner | Head of Frankfurt School Blockchain Center

If you have got this far, we hope that it has become apparent that the mobility industry is facing significant paradigm changes. Most stakeholders are adopting innovative technologies such as Artificial Intelligence and Blockchain. But it still has to be seen to what extent these are recognized early enough to become substantial building blocks for the future mobility service backends that must, in our opinion, be connected by an overarching strategy to develop trust and efficiency to enable new service models.

In this white paper we have shown, where and why it makes sense to adopt Blockchain technology and where it probably doesn't, we have identified DLT use cases from "low hanging fruit" to ambitious, complex projects. Critical infrastructure, such as autonomous vehicles, needs the highest trust and security available with dedicated hardware, and DLT brings just that. Traffic management and pollution control are problems looking for a solution, and beyond Proof-of-Concepts, more significant projects have started in the space.

We have also shown the need for collaboration, which fits well with the decentralised nature of DLT where a "rising tide lifts all boats". Best-of-breed ecosystems are also essential to mitigate risk, and decentralised governance further strengthens security and transparency. Successful Blockchain projects also require evolutionary use cases, where companies can collaborate on the big picture. Bold financial modelling is an integral part of creating such a holistic view where decentralisation is centre-stage. The hardware-based Car Wallet we described already exists. It makes many of the use cases described possible. Car Wallets also enable a longer-term vision of a tokenised economy in which vehicles play a role within future Smart City environments.

One of Blockchain's critical contributions to the automotive industry is to create a secure identity for all vehicles and other infrastructure. This makes them addressable. Our society and economy are both becoming more and more data-driven. The historical advantages of leading automotive stakeholders are at risk unless their data and business model strategies can be adapted. Leveraging DLT is an excellent place to start and will offer an ideal environment in which to create trust.

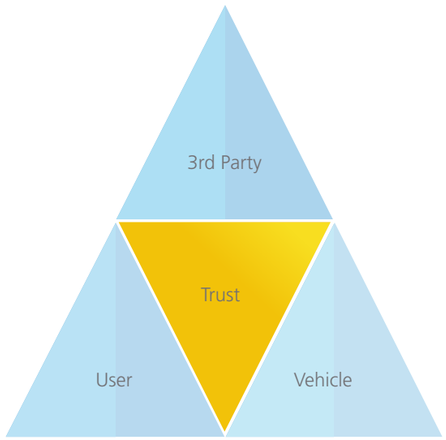

Figure 4: "Trust" as a prerequisite for communication and transactions between the user, the vehicle and 3rd parties

07

About the authors

About MHP

MHP is a globally active and leading management and IT consultancy. We develop groundbreaking mobility and manufacturing solutions for international corporations, established medium-sized companies and disruptive start-ups. As a premium business and technology partner, we are today shaping the digital future of tomorrow.

Our consulting approach is unique: We combine holistic IT and technology expertise with in-depth management know-how. This makes MHP the ideal partner for a successful digital turnaround. As digitalization experts, we provide innovative strategies based on well-founded analyses to transform change processes into lasting success.

With more than 2,500 employees at 13 locations around the world, we drive digital progress – in collaboration with more than 300 clients and with excellence at all levels.

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About RIDDLE&CODE

The leading European Blockchain interface company tackles the complexity of cryptography-related projects. RIDDLE&CODE creates solutions consisting of hardware and software stacks. The recent launch of a hardware car wallet helps to establish the prerequisites for future mobility solutions: Machine identity, authenticity, trust, addressability, and transaction capability.

RIDDLE&CODE combines the security of smart cards with the potential of cryptocurrency and IoT. RIDDLE&CODE achieves this by extending smartcard chips in both form and function. We can thus transfer the sophisticated security measures known from the credit card industry into the Blockchain world and the physical internet.

Together with its tier-one clients and partners, RIDDLE&CODE brings greater efficiency and new business models to the automotive industry, financial and energy markets, supply chain management, and the Internet of Things in general.

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> Engine reliability was the critical driver of trust in the automotive sector. Now though, the adoption of blockchain technology and interfaces in the mobility sector is increasing the importance of data, so that data security, authenticity, and privacy will also drive trust. This trust enables mobility-related services that will create disruptive new business models, going well beyond the examples that we've summarized in this Whitepaper. But the necessary technical building blocks are already available today.
>
> Alexander Koppel I CEO of RIDDLE&CODE

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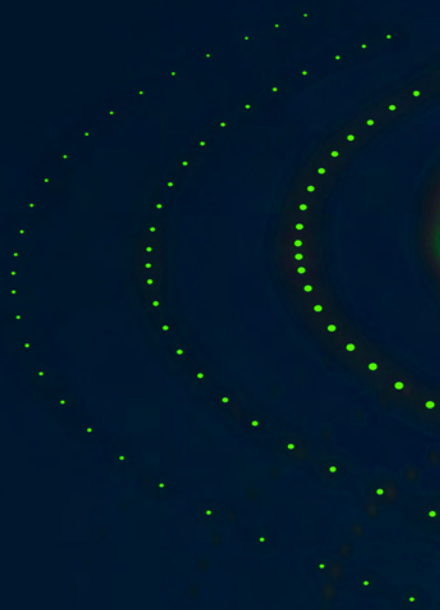

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