Constellation Network, Inc.
Research Collaboration Study

Why Automotive Data Exchanges Fail in a B2B Environment

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Abstract

Since the dawn of digitalization, data is an immersive force that surrounds our daily lives. With the wake of the knowledge and wisdom age, it has become an important economic determinant and is often perceived as one of the most valuable assets a company can have. As consumers we are all facing a situation where companies are competing to gather as much personal data as possible with the services and products they provide.

This research paper is taking a critical look at the data economy in its current state by combining the data value chain and concepts of platform and sharing economy, reapplied in the context of mobility: Is data really the new oil? And if so – what are the conditions to translate data to economic success?

Theoretical findings are tested with the use case of Uber to show how the scientific models and theoretic concepts are interwoven and form a real valid business model – again focusing on the data value chain.

Arguably, the Automotive industry is undergoing significant changes leading to a redefinition of business models and roles of actors within the sector. In this context, data play a major role. On the one hand, because they either drive or are driven by all major influencing trends in mobility such as connectivity, autonomous driving, sharing models or alternative fuels. On the other hand, most companies in the mobility space see data as the prerequisite to still play a role in the future and offer valuable services to consumers.

Consequently, there should be a flourishing ecosystem of mobility data and active exchanges between different actors that enable realization of visionary concepts.

Yet, during numerous conversations with business experts and analysis of the status quo, reality paints a different picture, especially in the context of car-based mobility and services. That is how the question came up: if everyone wants it and everyone keeps asking for it – why is it not happening?

To find out what hinders a functioning data exchange in the Automotive Sector at scale, first an understanding of data in the context of mobility ecosystems was created. Then, existing approaches and marketplaces have been analyzed and the findings were combined with generic studies, data exchanges in other sectors and economic concepts.

Based on expert opinions and market research, what we believe to be the actual challenge and reason for failing activities, has been distilled.

Data Economy

"Data is the new oil"[1] – arguably one of the most cited quotes in conjunction with digitization and a good opening that portrays the ongoing shift into the wisdom age[2] and the corresponding economic mechanisms. The scope of this paper cannot stray too much into the influencing factors. Yet, it will put certain assumptions to a test. There are three key assumptions that are important to understand the data economy and its importance:[3]

1. The importance of physical products and related services for unique value propositions and revenue streams is declining, as they increasingly turn into commodities
2. Data are the foundational layer of wisdom in a digital environment, which will be detailed further in the subsequent passages
3. Data have an underlying monetary value based on "knowledge is power"

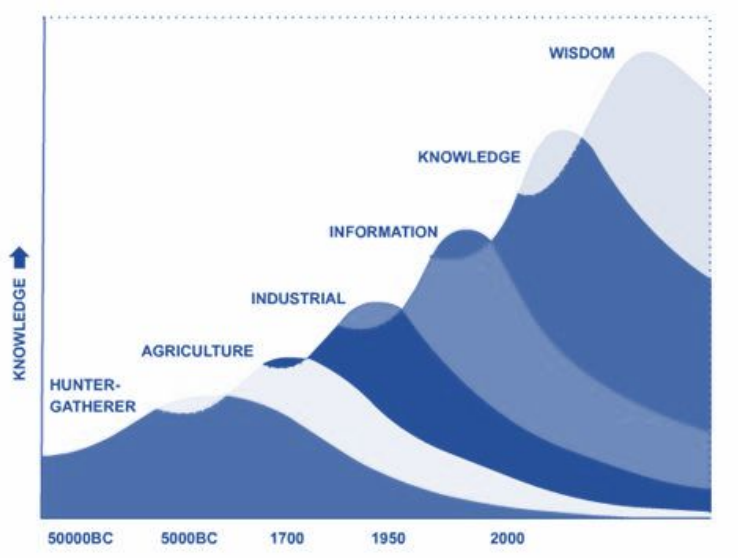

Fig. 1: Waves of social and technological change[4]

Increasing complexity and pace of changes and the inherent determinants cause business leaders to actively seek opportunities allowing them to dominate their markets in the wisdom era. A good practicable example is the evolving business model of Amazon in the last ten years. It started as an online store for books and has emerged into a multinational trading platform for almost anything one could desire. While the marketplace and related services still provide the economic backbone to the company, it has managed to diversify and increase the leverage of its purely digital offerings. The base layer for these offerings is the accumulated data lake. Combined with reduced fixed costs (as opposed to e.g. physical warehousing) associated with the digital portfolio mix, it has become an important driver of revenues. By adding digital products and services such as Audible, Prime and cloud services, Amazon not only diversified its revenue streams, but also supported financing its infrastructure, increased its customer

[1] Also sometimes referenced as "gold" instead of "oil" - https://www.economist.com/leaders/2017/05/06/the-worlds-most-valuable-resource-is-no-longer-oil-but-data
[2] http://thewisdomeconomy.blogspot.com/
[3] https://bit.ly/32mz858
[4] Picture source: http://thewisdomeconomy.blogspot.com/

lifetime value and built comprehensive profiles around customers. Now the company is rapidly shifting towards monetizing the data and wisdom it has built up with data-based services like Amazon Web/Cloud Services and dedicated offers to advertisers.[5]

The wisdom economy has strong interdependencies with growing digitalization in the 21st century. Data represents digital, machine readable information that translates into knowledge and wisdom. Hence, they form a foundational layer of wisdom in the digital age. The ever-growing amount of information is increasingly digested by machines, reinforced by growing availability and maturity of Artificial Intelligence and Machine Learning. Humans must rely on computing power to be able to consume the vast volume of data and information and turn it into actionable insights. The big data movement implies that more consumable data translate into more knowledge and hence more economic power.[6]

This is where the data economy comes into play. Economic power directly derives from monetization of a product, which is data. In that context, the basic components of any market theory and corresponding mechanism apply. A marketplace as the basis for any economy requires a buyer, seller and price for the product, which is normally determined by supply and demand.

Unfortunately, finding a fair market price for data is highly complex, as many influencing factors are involved. At its core, this is based on two facts: Firstly, there is no established global marketplace for data. Secondly, most datasets are not even remotely comparable, and the value attached to them is highly subjective.

Referring to the initial statement that data is the new oil, these facts can be illustrated: Oil as a raw material is traded on a global marketplace, which is not the case for data (as of now). While oil can be clearly quantified and priced (e.g. per barrel), this is not true for data: 1kb of raw data does not always have the same value. There is no generally applicable measuring unit.[7]

[5] https://fourweekmba.com/amazon-business-model/ ;
https://www.innovationtactics.com/amazon-business-model-ultimate-overview/

[6] http://diplomatic-world.com/?p=1965l ; https://www.sas.com/en_us/insights/big-data/what-is-big-data.html ;
https://www.ibm.com/analytics/hadoop/big-data-analytics

[7] https://www.un.org/development/desa/dpad/wp-content/uploads/sites/45/publication/FTQ_1_Jan_2019.pdf ;
https://go.forrester.com/blogs/help-wanted-data-innovation-for-the-data-economy/ ;
https://www.investopedia.com/terms/k/keynesianeconomics.asp ;
https://www.investopedia.com/terms/l/law-of-supply-demand.asp

Data Value Chain

To get a better understanding of the data economy, a closer look at the data value chain is helpful.

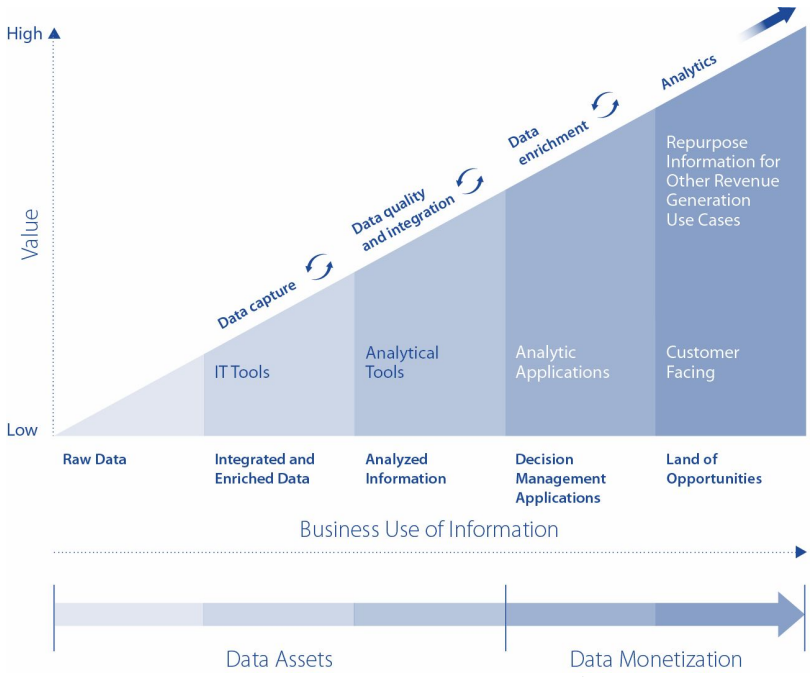

Fig. 2: The data value chain [8]

At its core, raw data provides little value. Given that a lot of literature suggests a great demand for data, this could be considered a bold statement: Market mechanisms imply that a great demand makes something valuable and drives the market price up.

Looking at the demand side, it is correct that not all market participants have the same prerequisites and access to raw data might be limited. Obtaining and storing raw data can be hard and might require dedicated efforts and resources – think of consumer data, production data or sensor data, among others. With limited accessibility, high demand normally constitutes high prices.

Yet, this only holds true if the actual supply is limited, resulting in a scarcity of the raw material. In reality, quite the opposite is true. Compared to oil, which is a limited resource and can only be consumed once, there is a plethora of data out there. The limiting factor is accessibility of the supply, i.e. data owners do not want to sell or cannot sell their good. Nonetheless, the principles of supply and demand indicate that an oversupply lowers the market price.

*So why are data still considered valuable and how is a price established? The analogy to oil can be used again: Raw data resemble crude oil, referring to a resource that, without refining, is useless. Data needs to be refined to become valuable. This refinement process includes structuring, analyzing and combining different datasets to turn them into actionable information and services. Hence, data is most valuable when it's an integral part of a customer facing solution – the end of the value chain. [9]

[8] Picture source: https://www.idevnews.com/stories/6998/The-Data-Value-Chain-Steps-for-Monetizing-Your-Data

[9] References data value chain: https://www.idevnews.com/stories/6998/The-Data-Value-Chain-Steps-for-Monetizing-Your-Data ;

If a company wants to find out if raw data is needed and where/how it should buy them, the value chain needs to be applied backwards. First, the final offering should be clearly defined. Based on this definition, the chain can be worked backwards to determine which raw data are required to generate the final product. As a positive side effect, by starting at the service and actual application layer, there is a clear definition of the user and the value that should be generated.

With a concept of the final product as the starting point, the company can determine what is needed to create it. In most cases, the core problem might not be the availability of raw data but the clear definition of a marketable service. It is vital to understand that in most cases buying data does not resemble the purchase of a final product, but raw materials or components that are needed to manufacture a service.

Think of it as a baking recipe with multiple ingredients: When one of the key ingredients for a meal are certain datasets, one automatically comes to the question of where they can be obtained and how they need to be prepared and processed. If the company does not have the required ingredients in house, it can start looking to source them externally. This is where a marketplace is created, and supply and demand come together.

In a metaphorical way, the data value chain follows the principle of WHY – HOW – WHAT: The definition of concrete sets of raw data (WHAT – the data input) comes last. Simply generating and hoarding them as the holy grail of economic success is a dangerous fallacy. The first step is knowing which service should create value for whom (WHY – the vision) and how the input should be transformed into this service (HOW – the refinement process). Otherwise data collection will only translate into having a warehouse full of raw materials with no production process or final product to use them.[10]

Bridging the gap back to the wisdom economy, data only represent the foundational layer to wisdom and decisions – or in economic terms – the final product/service.[11]

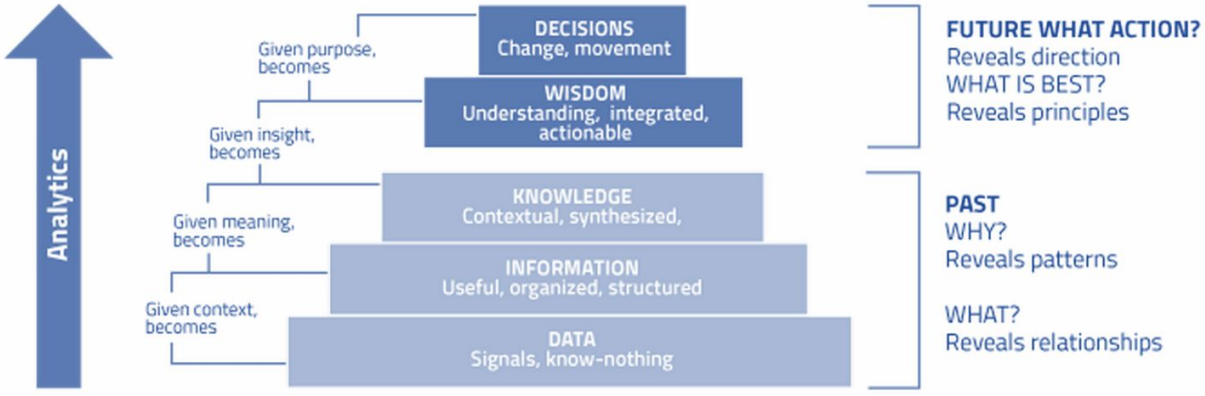

Fig. 3: Data and Wisdom (DIKW model) [12]

https://opendatawatch.com/reference/the-data-value-chain-executive-summary/ ; https://www.slideshare.net/rainer_sternfeld/designing-a-better-planet-with-big-data-and-sensor-network-for-isn-conference-philips-high-tech-campus ; https://www.bcg.com/publications/2019/big-oil-data-value.aspx ; https://www.ibmbigdatahub.com/blog/understanding-data-value-chain

[10] https://bit.ly/2B1Zm1F; https://www.scrum.org/resources/blog/why-how-what-product-vision-task ; https://innovationmanagement.se/imtool-articles/customer-centric-innovation/

[11] https://bit.ly/3fCQ8rO; https://www.certguidance.com/explaining-dikw-hierarchy/

[12] Picture source: https://www.i-scoop.eu/big-data-action-value-context/dikw-model/

Platform and Sharing Economy

The basic concept of any economy and exchange is founded on trading. These principles are rooted in times long before anyone was thinking of bits and bytes. In ancient times before currencies helped to establish a uniform expression of value, people were trading goods. A farmer exchanged his crops for wood with a lumberjack, a blacksmith traded metals for clothes with a seamstress. A fair price was established by bartering between both parties and supply met demand on public marketplaces.

While the methods and processes have evolved with time, the foundational principles remain the same. Every actor only has access to certain goods and offers them in exchange for goods that could not be accessed otherwise. Transferring this into the digital age, this leads to two essential enablers of a data exchange: platform and sharing economies.

Platform Economy

For platform economies, two prominent examples are eBay and Amazon. Both offer a digital marketplace that allows orchestrated trading with a focus on B2C and/or C2C environments. Both companies have already diversified their business models (also see section "data economy" and Amazon's fulfillment and logistics services), but at their core they created revenue from transaction fees. Their success is rooted in the fact that a trusted third party is needed to bring supply and demand together and manage settlement between parties.

In a B2B environment, one could use Alibaba as an example that adapted the main ingredients and created a marketplace for organizational buying. In recent years, a lot of startups spawned that also tackle the orchestration and automation of organizational buying on platforms – either public or private. All platform economies are based on the economic principles of network effects. In a nutshell – the larger the network, the more valuable the platform.[13]

Sharing Economy

Bridging the gap to data sharing, functioning peer-to-peer networks have been established in a C2C environment. Facebook allows users to exchange personal information with their peers, Instagram allows users to share pictures or videos, and file-sharing networks (e.g. torrents) enable the exchange of files. Surprisingly, these networks prosper even though there is no direct monetization of shared content for the creator (not considering sponsoring or advertising revenues created by influencers and companies).

Aside from mere data, functioning business models have evolved around peer-to-peer sharing networks that work in close conjunction with the principles of platform economy. Prominent examples are found in AirBnB or various car-sharing offers, among others. One could debate how much "sharing" is left in an orchestrated marketplace with the intention of a commercial exchange, but the roots of these platforms still stem in the concept of peer-to-peer exchanges.[14]

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[13] https://en.wikipedia.org/wiki/Platform_economy#Sharing_economy ; https://www.xing.com/news/insiders/articles/digital-business-models-and-platform-economy-1015352

[14] https://bit.ly/2DLos5T; https://www.forbes.com/pictures/eeji45emgkh/airbnb-snapgoods-and-12-more-pioneers-of-the-share-economy

Coming back to data, consumers often willingly share their data with corporations even for free because in return they receive value in form of services that simplify their decisions and actions. These exchanges do not happen on a public platform but are usually integrated in a direct contractual relationship between both parties. We share the location data of our smartphones with Google and Apple, expose our buying behavior with our Payback card and give car manufacturers access to our telematics data. Again, consumers are normally not paid for sharing their data but still agree (also known as opt-in) to do it.[15]

On the contrary, in B2B markets, a 2018 study by PwC has shown that only 10-15% of interviewed companies exchange data with other corporations outside their own supply chain. Shockingly low numbers compared to B2C and C2C environments. To establish a prospering B2B data exchange, The Industrial Data Space initiative was proposed as a solution.[16]

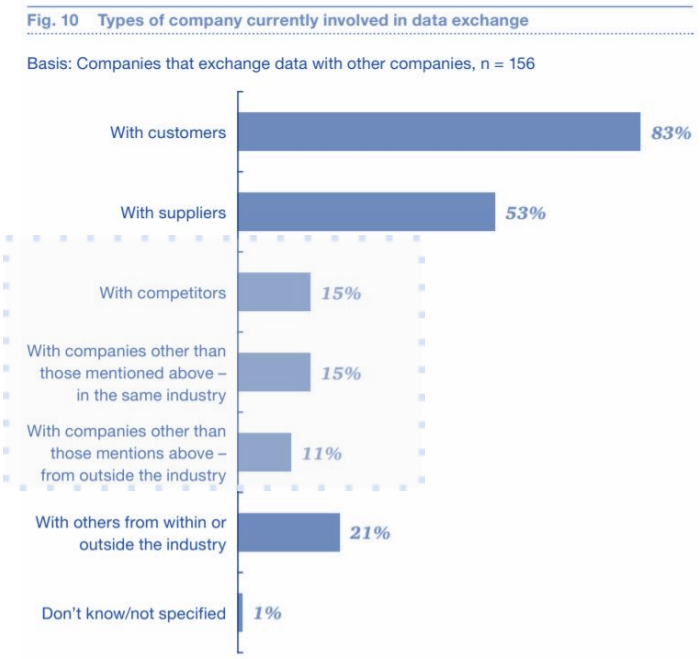

Fig. 4: PwC research on B2B data exchange [17]

These findings pose the question why data exchanges and sharing seem to work fine in a B2C and C2C environment while the B2B world is struggling with an open exchange.

Understanding the key ingredients of prospering data exchanges in the consumer world helps to identify shortcomings in the industrial sector:[18]

/#725cce8c52cf ; https://www.weforum.org/agenda/2019/01/sharing-economy/ ; https://www.amazon.com/Sharing-Economy-Employment-Crowd-Based-Capitalism/dp/0262034573

[15] http://www.businessdictionary.com/definition/opt-in.html ; https://gdpr.eu/gdpr-consent-requirements/

[16] https://www.pwc.de/en/digitale-transformation/data-exchange-as-a-first-step-towards-data-economy.pdf

[17] Image source: https://www.pwc.de/en/digitale-transformation/data-exchange-as-a-first-step-towards-data-economy.pdf

[18] https://bit.ly/2OohqGa

- Trusted Third Parties act as an intermediary to facilitate peer-to-peer transactions: The Platform as a marketplace.[19]
- A perceived value or service in return for data, creating non-monetary incentives and motivation, such as:[20]
    - Consumers receive more convenience and a better personalized service (e.g. Google Maps traffic data, BMW Connected Services)
    - Social recognition (Social Media)
    - Access to new resources/content (file-sharing)
- Network effects: The more active users on a platform, the more attractive it becomes[21]

B2B sectors struggle with leveraging these factors for several reasons. Few companies willingly transfer platform ownership to another corporate party that is then seemingly more trusted than other participants. They usually also lack non-monetary incentives, given that maximizing profits is a primary goal for any profit-oriented company. And while network effects might require a lower total number of users, they are more difficult to initiate due to legal constraints and complex contractual agreements.

[19] http://www.businessdictionary.com/definition/Trusted-Third-Party-Services-TTP-Services.html
[20] https://bit.ly/2OsL5Ot; https://go.ey.com/2AZbhNw
[21] https://bit.ly/307xykU; https://bit.ly/2CzRViw

Use Case: Uber

Business Model in a nutshell

To bridge the gap to the mobility sector and combine the theories of data, platform and sharing economies, Uber is a good example. The business model and success of Uber are a great showcase of the convergence of data, platform and monetization for the consumer side.

At its core, Uber uses a platform economy based on a two-sided marketplace as their business model. The platform connects drivers and riders to allow for cost-efficient end-user mobility. On a strategic level, it replaces the middlemen (fleet operators like taxi companies, car-sharing providers, public transport agents) to connect driver and rider directly.[22]

Thereby, mobility is offered to consumers who do not own a vehicle or cannot use their privately-owned vehicle on a certain journey for whatever reason. On the other hand, every car owner gets the opportunity to earn money by offering rides. Revenue streams come from transactional fees and partnership offers. The expansion of the platform into new customer segments is already on its way with offers like UberCARGO and UberEATS.[23]

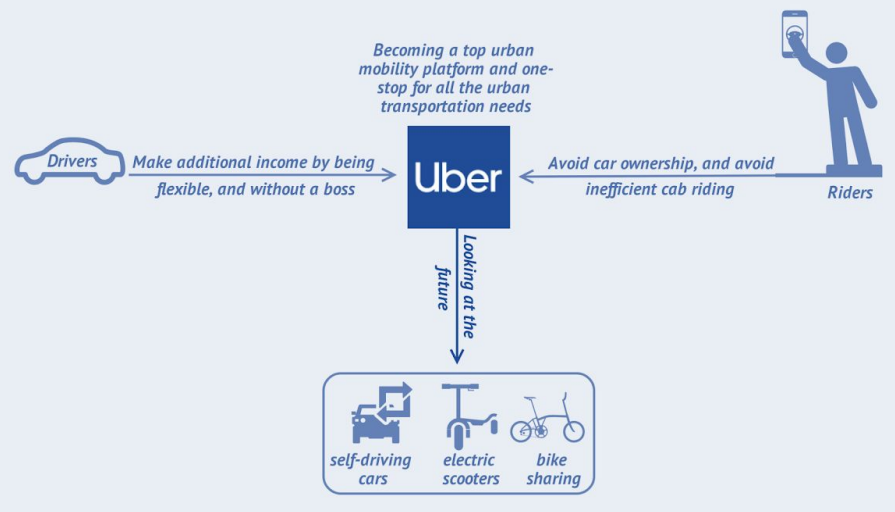

Fig. 5: Uber business model visualized [24]

Uber's business does not focus on owning any physical assets as opposed to a car rental company or other fleet operators, making it a perfect fit for this research paper. The entire business model is based on a data-driven digital service offering. This allows for a highly scalable architecture that can be duplicated in new regions, for new customer segments and new modes of transport aside from passenger cars. The architecture offers the basis for an exponential, highly adaptable offering.

[22] https://fourweekmba.com/uber-business-model/ ; https://mobisoftinfotech.com/resources/blog/uber-business-model-explained/

[23] https://www.businessmodelsinc.com/exponential-business-model/uber/ ; https://www.investopedia.com/ask/answers/013015/how-do-ridesharing-companies-uber-make-money.asp

[24] Picture source: https://fourweekmba.com/uber-business-model/

Uber and the data value chain

Coming back to the data value chain, Uber started at the end with a clearly defined service and the actual product they wanted to offer – including a value proposition for the defined customers (drivers/riders) to make it happen. Presumably, they then worked their way down the data value chain to define which raw data were needed to accomplish it and how those data could be acquired.

The raw data needed is rather primitive: GPS/location data to offer rides and personal data of participants to allow transactions between them. Uber did not have these datasets to begin with, so the question was how to obtain them. While third parties might offer them, the need of real-time location datasets and personal information required them to generate and secure the data themselves instead of only relying on an external vendor (licensed third-party geolocation services are still used).

The easiest source to obtain both datasets are smartphones. Hence, Uber created an App/website and easy-to-use interface for its customers to collect the required raw data. In order to motivate users to share their data, the value proposition had to be strong enough to incentivize. On the driver side, Uber offered the opportunity to monetize privately owned vehicles in a self-employed fashion with additional benefits compared to working as a taxi driver. On the passenger side, users received cost-efficient individual transportation that removes the hassles of finding and ordering local transport as well as the lack of price transparency and cashless payment options. There are additional value propositions but solving these pain points added enough value for both parties to jump on board.[25]

By offering an attractive service for both drivers and riders, augmented with elements of gamification and community, Uber offered strong enough incentives. Users created accounts and committed to share their data in return for receiving the service. At this point Uber secured the raw data it needed. However, as pointed out earlier, this is only the starting point for value creation. So how did they process and refine raw data to achieve the final service?

Ubers architecture uses a hybrid cloud model for storing and processing data, combined with various big data analytics tools to refine data and turn them into actionable information for the service offering. Different stacks are utilized and incorporated into an interoperable microservices system (described as a tree like structure by Uber). The actual magic happens when different datapools are combined - raw data collected from users and third-party data are ingested and merged, utilizing machine learning and artificial intelligence algorithms (e.g. Uber Michelangelo).[26]

A crucial take-away at this point: Combination of different datasets and third-party services are an important success factor. Among other technology partners, Uber utilizes Google Maps Services for their mapping, matching and routing services, combined with their own raw data of platform users.[27]

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[25] https://eng.uber.com/tech-stack-part-one/ ; https://www.investopedia.com/articles/investing/030916/how-uber-uses-its-data-bank.asp ; https://www.wired.com/story/how-maps-became-the-new-search-box/

[26] https://eng.uber.com/tech-stack-part-one/ ; https://eng.uber.com/tech-stack-part-two/ ; https://eng.uber.com/scaling-michelangelo/ ; https://medium.com/@narengowda/uber-system-design-8b2bc95e2cfe

[27] https://www.cnbc.com/2019/04/11/uber-paid-google-58-million-over-three-years-for-map-services.html

On the customer platform level, the core service is offered with a payment layer powered by Adyen, combined with the personal data of users.[28] The scope of this research paper cannot cover all facets of how Uber created a valuable service from raw data. However, the key message is: It is not the original raw data creation that creates the biggest value. Arguably, data creation and monetization are a side product of the actual value proposition – albeit reinforcing and mutually supporting, it wasn't the primary focus to begin with.

Today, Uber is also able to sell collected and refined data to other parties like municipal partners, automotive companies or hotels, but value and monetization predominantly come from the service layer. And it is only through the combination of data, analytics and algorithms from various providers and diverse datasets that this service can be offered. It is not about the data, but what you do with them, that defines value.[29]

The pillars of Uber's success in relation to the data value chain:[30]

- **Data feed:**
  Service with strong value proposition that incentivizes sharing of location and personal user data

- **Data capture/storage:**
  App and platform with comfortable User Interface and lock-in effect that captures user data and allows low latency storage/ingestion in backend

- **Data enrichment:**
  Highly scalable backend service architecture for data processing and analytics that combines own data feed with third-party feeds, tools, applications and algorithms to create the information needed for the service

- **Customer facing service:**
  Combining the mapping (routing/matching), payment and platform layer into repurposed information that constitute the payable service

In its service layer, Uber brings together the concepts of platform, data and sharing economies. They seamlessly converge into an offering that grows in value with the network effects as the platform expands. For riders and drivers, Uber is the trusted third party that orchestrates the marketplace and handles the transactions between supply and demand side.

Understanding how these concepts tie together provides useful insights for the subsequent evaluation why B2B data marketplaces tend to fail.

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[28] https://bit.ly/3fwcGKt; https://bit.ly/2WmtyM9

[29] https://www.investopedia.com/articles/investing/030916/how-uber-uses-its-data-bank.asp ; https://movement.uber.com/?lang=en-US ; https://www.wired.com/story/how-maps-became-the-new-search-box/

[30] In-depth information on Ubers architecture: https://eng.uber.com/ ; https://medium.com/@narengowda/uber-system-design-8b2bc95e2cfe

Data Marketplace & Exchange in the Automotive Industry

The Automotive Industry is undergoing a fundamental change that redefines market mechanisms and the roles of players in the value chain. While a magnitude of macroeconomic and microeconomic factors influences the ongoing shift, the most relevant are summarized under the CASE acronym. CASE stands for Connected, Autonomous, Shared and Electric and was mainly framed by Daimler. This acronym gives a great overview of the most influential determinants of the shift, which again branch out and are interconnected with each other as well as surrounding trends.[31]

- **Connected**
  Vehicles are increasingly connected with everything (so called V2X communications). This includes, but is not limited to: Drivers, infrastructure, other vehicles, and third-party service providers. Communication is based on connectivity (e.g. 5G networks) and a constant data exchange between vehicles and the mobility ecosystem.[32]

- **Autonomous**
  The vision of self-driving vehicles is gradually becoming reality. Based on the SAE automation levels ranging from 0 (no automation) to 5 (full automation), current vehicle generations are between level 3 and 4. Automation is based on different sensors, processing power, algorithms, machine learning/AI and the ability of vehicles to exchange data with other actors in traffic (machine or human).[33]

- **Shared**
  The deeper meaning of shared is a change in the concept of ownership and per se not limited to mobility. In the vehicle context, it subsumes car-sharing, ride-hailing, public transport and other fleet services that do not constitute private ownership and sole use of a vehicle by a single person. Vehicles can still be privately owned by one consumer but shared with other riders against a fee (see: Tesla robotaxi, in conjunction with autonomous driving). Arguably, shared mobility represents not only a technological shift, but also a change in mindset how the overall concept of mobility is perceived – with potential far reaching implications on value chains and the role of established actors. From a technological viewpoint, shared concepts demand data exchanges between involved parties inside and outside the ecosystem.[34]

- **Electric**
  Electric stands as a synonym for engines that are not based on fossil fuels and includes hybrid drives, purely battery powered vehicles, fuel cells and alternative synthetic fuels. For all systems, new infrastructural solutions are mandatory and require data exchanges between vehicles, passengers and the infrastructure (e.g. smart grid and charging points).[35]

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[31] https://www.daimler.com/case/en/
[32] https://www.zdnet.com/article/what-is-v2x-communication-creating-connectivity-for-the-autonomous-car-era/
[33] https://www.nhtsa.gov/technology-innovation/automated-vehicles-safety
[34] https://techcrunch.com/2019/04/22/tesla-plans-to-launch-a-robotaxi-network-in-2020/ ; https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/how-shared-mobility-will-change-the-automotive-industry ; https://www.rolandberger.com/de/Publications/Shared-mobility.html
[35] https://afdc.energy.gov/fuels/ ; https://www.fueleconomy.gov/feg/current.shtml ; https://www.smartgrid.gov/the_smart_grid/smart_grid.html

All of these major drivers have one thing in common: They require data as the fuel for future mobility ecosystems. In that way "data is the new oil" is a correct statement, if oil is used in a broader meaning of fuel. However, the complexity of a mobility ecosystem is immense, and a functioning ecosystem requires prospering data exchange and collaboration between all actors.

Mobility Ecosystems

By definition, a mobility ecosystem encompasses all modes of transportation, a multitude of brands, single entities and subsystems that provide transportation, the infrastructure itself – roads, traffic signs, electric grid – as well as other supporting actors. And ultimately, the consumers that require mobility. These moving parts are all interconnected and interdependent.[36]

Normally, a mobility ecosystem includes all aspects and functions that provide transportation, be it short-, mid- or long-distance. Yet, a holistic scope on mobility that connects all dots becomes extremely complicated: Various modes and providers of transport must be taken into account, different localities and infrastructures in one country have to be aligned. Internationally, even multiple languages, different time zones and currencies must be considered. Hence, for the following model of data exchange in the ecosystem, the scope will be limited to urban mobility within the territory of a single city.[37]

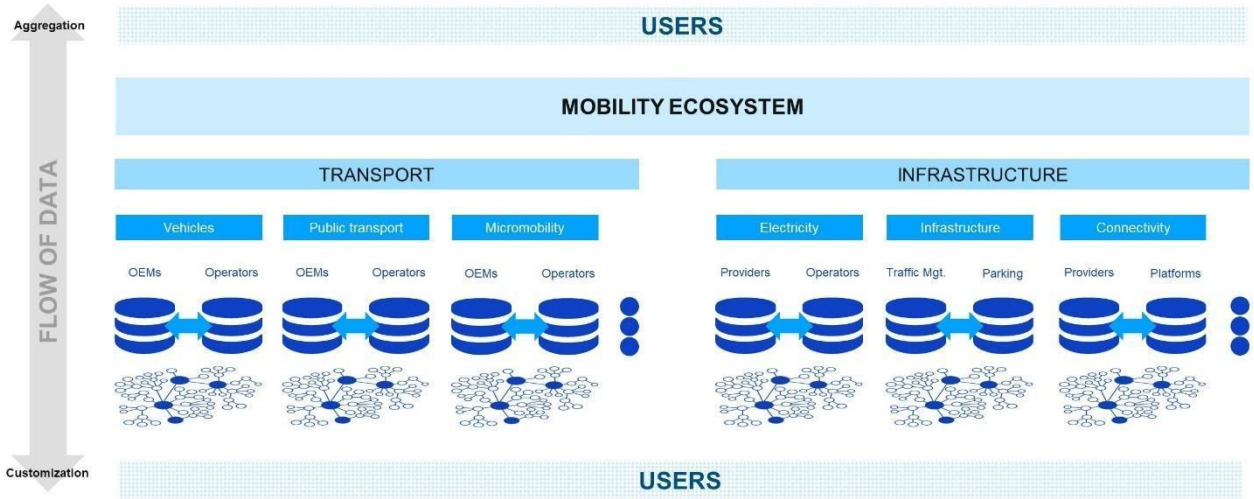

Fig. 6: Mobility ecosystem and data interdependencies[38]

Imagine a city as a manifold: Different components play together like gears in a well-oiled machine to form the overall concept of the city. This metaphor is also true for an urban mobility ecosystem. The foundational layer is formed by the urban population that needs transportation for daily routines and leisure. It can choose between different means of transport, depending on the situation and reason for travelling: A privately owned car, public transport, bicycle or shared mobility offers with several types of vehicles. Most journeys even combine at least two or more of these means. They can be best summarized

[36] https://medium.com/@moveco.io/mobility-ecosystem-a-wave-of-transformation-c8f2eb7af658 ; https://www2.deloitte.com/us/en/pages/manufacturing/articles/the-evolving-mobility-ecosystem.html

[37] https://www.adlittle.de/en/insights/viewpoints/integrated-mobility-platforms ; https://www.mckinsey.com/business-functions/sustainability/our-insights/urban-mobility-at-a-tipping-point ;

[38] Picture source: Own illustration

as the vehicle layer. Aside from the vehicle layer, there is also the infrastructural layer, including locations, the electricity grid and traffic management, among others.[39]

From a data viewpoint, there are data silos on every aggregation point. Each consumer has their own set of devices, applications and services they use. We call this the personal network, involving the individual datasets every inhabitant owns and shares.

On the vehicle layer, every offer has its own siloed data network that incorporates routing, booking or payment services, among others. Good examples are the data networks of bus, train and taxi providers, car-sharing fleets or the data-driven services of every vehicle manufacturer. These siloes can intertwine within the vehicle layer, for example if a car-sharing fleet uses cars of multiple makes: Every car and car maker has their own branded network and portfolio of services, which are then combined in symbiosis within the network of the fleet operator (e.g. for telematics data). Aggregation of silos happens on various levels and in multiple combinations.[40]

By exchanging data between the consumer and vehicle layer networks, mobility offers are created. These offers are connected to the infrastructural layer that has its own set of secluded data networks required for traffic management, telecommunications or energy supply within the city. A practical example can be given with Tesla's (and other OEMs) charging services, that allow the consumer to search for available charging points based on their location and incorporate charging dynamically into routing services. Especially regarding electric and autonomous vehicles, an open data exchange between the infrastructural, vehicle and even consumer layer is mandatory.[41]

In the grand scheme of things, there is an assembly of different clusters of data that at least must share subsets of their information with other clusters to allow seamless mobility and enable the influencing trends of future mobility. To allow for a functioning ecosystem, data must transcend between clusters and be aggregated on a superseding layer, described as the ecosystem layer.

When data comes back to the consumer layer, any preceding aggregation is transformed back into individual services. As an example: A user wants to know which means of transport bring him to his destination in the cheapest, fastest and most comfortable way based on his current individual location and purpose of the trip. While this information comes from the aggregated ecosystem layer, it needs to be transformed into a meaningful individual service for a singular user. Using the previously described Uber use case as an example, aggregated data from the ecosystem (e.g. traffic information) are translated back into an individual customer service that matches rider and driver based on location and destination.[42]

Despite the goals of free and open data exchanges, existing silos and clusters cannot be broken down entirely, as they all form ecosystems within their own rights. Imagine it as the clustered subsystems feeding the overall ecosystem machinery. In this context, it is not in the best interest of all ecosystem

[39] https://www.sbdautomotive.com/en/news-automakers-goldmine ; https://www.adlittle.com/futuremobilitylab/assets/file/180330_Arthur_D.Little_&_UITP_Future_of_Mobility_3_study.pdf

[40] https://www.mckinsey.com/business-functions/sustainability/our-insights/urban-mobility-at-a-tipping-point ;

[41] https://assets.kpmg/content/dam/kpmg/br/pdf/2017/11/br-kpmg-congresso-sae.pdf ; https://www.tesla.com/support/charging

[42] https://www.adlittle.de/en/insights/viewpoints/integrated-mobility-platforms ; https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/reimagining-mobility-a-ceos-guide ; https://360.here.com/why-data-is-key-to-the-future-of-mobility-and-smarter-cities

participants if those subsystems were removed entirely. The core challenge is defining which information has to be shared with whom in which form and time.

This is based on several reasons:[43]

- **Network security**
  Each cluster must ensure its own security and stability to allow for ecosystem safety. If network security is only nested in the top layer, one bad actor can jeopardize the safety of the entire network – a single point of failure would be created.

- **Core function**
  Every network serves its own specific purpose that it cannot give up – supporting the mobility ecosystem data exchange is often only a part of the core functions. For example, grid operators have to ensure that electricity is readily available. And that is not limited to vehicles, but also to private households or life-saving appliances in a hospital.

- **Individual service layers**
  Services are built within each cluster and form the touchpoints with consumers. While vehicles of different makes must communicate with each other for autonomous driving, each manufacturer still offers users branded personalized services based on their own network capabilities. The same applies to providers of public transport and mobility offers like Uber or Lyft, among others.

- **Ownership and monetization**
  Data privacy and one to one contracts (via opt-ins) between parties play a role in every cluster. However, this does not only refer to legal implications, but even more so to the beforementioned service layers. If services only happened on the aggregated ecosystem layer, each cluster would be degraded to a data provider and monetization would primarily happen at the top. Now, the question is: Who owns the top layer of a mobility ecosystem and makes service contracts with users – Is it the municipal authorities? Google? Or one of the players in the clusters below? Not only would players in the clusters be less likely to support a totalitarian approach, it is also questionable if such an architecture would be beneficial to the entire system.

It becomes apparent that a functioning mobility ecosystem requires data exchange between involved parties. The further data moves up the ecosystem, the more it is aggregated. The further it moves down the chain, the more it is individualized. Knowing that the entity of the ecosystem comprises a magnitude of data silos that have to interact but cannot (and should not) be broken down entirely is key to finding a viable solution.

[43] https://mck.co/3h6KeiD;
https://www.detecon.com/en/knowledge/maas-and-data-sharing-five-issues-closely-related-practice ;
https://www.pwc.de/en/digitale-transformation/data-exchange-as-a-first-step-towards-data-economy.pdf

Approaches and problems of data marketplaces in the Automotive industry

Numerous players need to collaborate in the interwoven mobility ecosystem to enable the transition into a "Mobility as a Service (MaaS)" world. A term that is often used in this context is coopetition – cooperation on the network level and competition on the service level. Information and data have to transcend organizational boundaries and must be shared between multiple companies and even industries.[44] Since most players pursue divergent goals or compete on the service layer, data exchange should be orchestrated in the form of a mediating marketplace.

Even though it is a massive coordinative challenge to implement such a universal marketplace, multiple platforms and initiatives have emerged over the recent years to tackle the problem. And within certain secluded segments there have been successful examples, mainly driven by OEMs.

When several OEMs teamed up to acquire shares of HERE with the goal to create a unified database for mapping and improving in-car services, the industry leaped in the right direction. As another example, BMW created a cloud-based platform with IBM to enable third party services based on connected car data that was initially planned to be open to other OEMs as well. In 2018, Daimler and BMW created a joint-venture merging their mobility services to offer consumers a better experience. However, these efforts are still far from open data exchanges and mostly resemble extended data silos between a handful of actors.[45]

Independent of OEM efforts, there are a lot of startup companies, mature corporations and public institutions that have launched platforms with the promise to facilitate an open data exchange. A more detailed list of platforms and initiatives can be found in the appendix. Yet, all these efforts still lack traction and there has been no global breakthrough. Clearly, the problem does not lie in missing activity. Considering all actors know that an open exchange of mobility data is the foundational layer for meaningful services and future offers, the question is: what stops them from just doing it?[46]

To get a deeper understanding of pain points and why mobility data exchanges are struggling to gain traction, existing platforms and related market studies have been analyzed. Overlaying the findings, five major pain points that hinder open mobility data exchanges were identified.

1. Data sharing standards

A universal shared data framework for the mobility sector still needs to be defined. It is less about technical hurdles – a common rule is that structured data in machine readable formats are preferred choice. The bigger issues are access rights and format as well as infrastructure of datasets.

Players closely guard the data for their own use and treat their inventory as proprietary. A consensus for data access rights and the degree of openness is required to establish a functioning data exchange. All data would either have to be openly accessible or the relevant datasets for a functioning mobility ecosystem have to be identified and only those are made openly available.

[44] https://bit.ly/3jasxAW; https://maas-alliance.eu/ ; https://www.investopedia.com/terms/c/coopetition.asp

[45] https://bit.ly/3fDbANm; https://www.ibm.com/blogs/cloud-computing/2017/06/16/bmw-ibm-cloud-cardata/ ; https://www.bbc.com/news/business-47332805

[46] An overview of initiatives and analyzed platforms for this paper can be found in the appendix

In both cases, clear general conditions for frequency and form of the disclosures and the actual setup of acquisition are required. However, as of today all players still structure their data in different ways and do not share the same datasets. Also, the infrastructure to obtain datasets varies, with some players offering API call pull mechanisms, others using push notifications and others utilizing live streaming.

Arguably, a totally open exchange would support innovation and excel transitional speed of the ecosystem by allowing data-based services to prosper. What becomes apparent is that all initiatives suffer from an unclear distribution of roles and tasks: Who decides what is public and what remains private, who manages access rights, who supplies and who consumes. It remains questionable if roles and privileges can be clearly assigned and if they should be, as an unequal distribution of rights might hinder sharing of information.[47]

2. Quality of data

Mobility services depend on up to date, reliable, and adequately complete data within the ecosystem. Especially for applications needing real-time data, the half-life is extremely short. A lot of data must be updated daily, hourly, or, in some cases, every second. If a service provider wants to acquire datasets he needs to know that he receives quality – reliable sets without corrupt data. In that manner, quality does not only involve refresh rates, but also quality of the supplied datasets, referring to associated data points, format and structure.

A general rule for quality of datasets is that the information extracted from them have to serve a purpose in a specific context – or simply put: fitness for use. Usually, data quality is assessed along the following dimensions: accuracy, completeness, consistency, validity, integrity and timeliness/currency. However, given the magnitude of potential use cases for data in a mobility ecosystem, a universally applicable consensus on the level of quality can be hard to define without centralized governance.

The perception of quality in data is thus largely built on trust. Without knowing if a source can be trusted, a mediating trusted third party or product samples that give the consumer the chance for a product trial are required. This follows the logic of "what you see is what you get" and "you get what you pay for" to establish trust. However, no data supplier wants to hand out freebies, as it reinforces a freeloader syndrome: Taking the data one can get, without sharing their own.[48]

3. Monetization of data

Considering the data value chain, data suppliers have no interest in sharing their information for free. Companies with access to raw data hoard them and have no natural interest in sharing, thereby

[47] https://ladot.io/wp-content/uploads/2018/12/What-is-MDS-Cities.pdf ; https://www.forbes.com/sites/reginaclewlow/2018/10/10/the-opportunity-to-reshape-cities-with-shared-mobility-data/#5cb5ff3e617f ; https://www.detecon.com/en/knowledge/data-sharing-age-mobility-service ;

[48] https://www.detecon.com/en/knowledge/maas-and-data-sharing-five-issues-closely-related-practice ; https://medium.com/datacrat/data-quality-dc4018fc443 ; https://smartbridge.com/data-done-right-6-dimensions-of-data-quality/ ; https://blog.syncsort.com/2019/07/data-quality/5-characteristics-of-data-quality/

creating data silos. Data owners are afraid to openly share or sell their data because they risk missing out on more valuable applications or services someone else could build with them.

Interestingly, nobody can know all potential mobility services that could evolve from existing datasets at this point. As a fact, no one can own or control the entire data value chain, as applications and services mostly require combining data from various sources. Consequently, even though everyone knows that cooperation is required, the fear of missing out is obstructing a prospering ecosystem. Everyone is afraid to sell a raw dataset for $10 now, but in a future service it could be worth $1,000. It is a Gordian Knot: Services mostly require combinations of datasets. Yet, every data provider would much rather offer the final service himself instead of supplying data to others.[49]

Even if the provider is willing to sell his data, there is no universal measuring unit or definition for the value of data, as it is mostly based on perception and individual motives. Every dataset is different and for maximum use and interoperability, raw data need a level of normalization. Establishing a fair price for datasets still typically requires negotiations in individual deal flows between buyer and seller. Yet, data buyers are hesitant to buy, because accessible data might already have been tampered with and there is no comparative market price.

It lays within the nature of private companies to be profit-oriented. Hence, sacrificing potential business models for the greater good is against their nature. Enforcing this through public organizations and governmental ruling could be a distortion of competition. In addition, processing and making data available in good time simply costs time and money, so free sharing is a calculatory loss for the provider.

Consequently, there is a lack of monetary incentives in sharing data. The only non-monetary incentive is the exclusive access to other mobility data through sharing, similar to peer-to-peer file sharing. But this only works if there is a consensus on open sharing and everyone plays by the rules. This is also where the network effect comes into play, as the value of the exchange increases with active participants – so who will make the first move?

4. Ownership models

Control and ownership of aggregated data results in economic power. Hence, most actors pursue assuming the role of integrators and aggregators – in other words: mobility service providers. As a result, other actors would be degraded to data suppliers missing out on the monetization opportunities in the service layers. Naturally, this creates conflicts of interest. On another note, legal transfer of data ownership can be an issue if personal data based on previous opt-ins are involved.

Following this logic, whoever manages the top layer of the mobility ecosystem has the most power. The question is if the public sector can and should orchestrate the entire ecosystem or if it should be left to the private sector and free market dynamics to define who takes control. Both scenarios do not necessarily support a flourishing data exchange between all actors. At the end, it is debatable if the system needs a holistic integrator at all or if it can be managed decentrally.[50]

[49] https://www.detecon.com/en/knowledge/maas-and-data-sharing-five-issues-closely-related-practice

[50] https://www.detecon.com/en/knowledge/maas-and-data-sharing-five-issues-closely-related-practice ; https://assets.kpmg/content/dam/kpmg/br/pdf/2017/11/br-kpmg-congresso-sae.pdf ; https://www.adlittle.de/en/insights/viewpoints/integrated-mobility-platforms

5. Security

There are two major concerns that are closely linked to each other: Protection against malicious attacks (cyber security) and data privacy. The data exchange needs to be secured at the actor and network level to provide the necessary level of protection and prevention of a single point of failure. Especially in combination with autonomous driving, security of data transfers is top priority.

Another factor is protection of personally identifiable data: A unified approach to protect consumer data is required, which involves legal, technical and ethical considerations. Pseudo-anonymous data can be reengineered to reveal identities, e.g. by cross-referencing location and other datasets. Reverse engineering of personalized data must be prevented in the design of the system architecture to comply with data protection laws. In addition, consent structures must be set up for personal data or datasets have to be anonymized to a degree that does not require individual consent of end users.[51]

[51] https://bit.ly/2Wl59GS; https://www.information-age.com/front-line-cyber-security-mobility-123471096/ ; https://www2.deloitte.com/us/en/insights/focus/future-of-mobility/cybersecurity-challenges-connected-car-security.html

Conclusion: The True Challenge

Mobility data platforms can serve as a great catalyst for sharing data and orchestrating the exchange between involved parties. Yet, there are two dimensions that hinder a scaling implementation.[52]

Technological

The platform architecture needs to reflect requirements of the ecosystem and the diverse roles among actors. This involves access rights, data standards, security and mechanisms of transactions, including the infrastructure that enables monetization and ownership models.

While it is beyond doubt that technical design and implementation of a functioning data exchange are demanding and a complex endeavor, all challenges are technologically solvable. Looking at existing data exchange platforms, technological setup is a challenge, but not a showstopper.

Economic

Monetizing the data exchange is deeply connected to ownership concepts and establishing a fair price. With the data value chain in mind, a universal pricing model for datasets on an open marketplace is questionable. Every actor associates an individual value to data, based on what they intend to do with it and what they need it for.[53]

Based on our findings, the root cause for lack of traction lies in the economic design. All offerings follow the same principle: Establish a marketplace business model with the platform serving as the middlemen between data suppliers and data buyers. The platform earns money with transactional fees, i.e. gets a cut of every data exchange that takes place on the platform.[54]

This poses economic and psychological barriers that prevent acceptance and scaling. The value proposition of existing offerings is to orchestrate transactions and data and bring buyers and sellers together. While this works great in a B2C environment, it creates reluctance in a B2B marketplace, especially if the traded good is data.

1. **Platform ownership**
   All actors would have to rely on the platform owner as the trusted third party that guarantees quality of data and fair trade standards. While the trusted third-party concept works well in the consumer world, is it hard to transfer into a business platform due to the distribution of power between marketplace owners and participants. Why should any company be more trustworthy than the others, if all actors are to be perceived equal?[55] A public organization as a neutral body in the middle could solve this problem, but it will pose other challenges like technical capabilities, and revenue stream management.

[52] Also see: https://bit.ly/2Osi5GG; https://pwc.to/3h5z0eC
[53] https://bit.ly/3euDE3V; https://www.pwc.co.uk/data-analytics/documents/putting-value-on-data.pdf
[54] Examples: https://www.caruso-dataplace.com/ ; https://bit.ly/32mLeLp
[55] TTP concept: https://csrc.nist.gov/glossary/term/Trusted-Third-Party

Regardless of the platform owner, a central issue remains unsolved: With highly diverse datasets that do not have a universal value, it is almost impossible to establish fair and transparent pricing. Consequently, prices will have to be determined individually based on the quality of the dataset and perceived value to the buyer.

2. Platform Monetization

Most actors are businesses and as such see themselves in a position where they could potentially establish their own data platform. Since companies know about the value of platform economies, most of them see strategic relevance in pursuing their own platforms to stay in control and maximize revenues. In contrast to consumers, companies prefer not having to rely on a middleman. With the economic power associated to FAANG (Facebook, Amazon, Apple, Netflix and Google)[56], most companies seek to enter the realms of mighty platform providers themselves and maximize returns of data transactions. As a result, competition is already happening on the platform layer between the actors.

On the transactional layer, players do not willingly let another actor earn a cut on their datasets. From a data supplier's perspective, why should another party monetize their value creation (supplied datasets)? From the consuming end, why should a middleman increase prices with a fee markup when buyers could potentially source the required data directly from the supplier in an over-the-counter (OTC) trade manner? If all actors in a mobility data exchange should be treated equally there would be a disparity of power if one company owns the marketplace without adding a clear value that could not be provided in another way. The result would be a distortion to competition, which reduces the willingness for active participation in transactions significantly.

3. Data Monetization Design

All existing platform architectures are designed to establish one-off trades. Datasets are offered at a fixed price and once the transaction is made, ownership is transferred, and the price is paid. This design will hardly work for an open B2B data exchange in the mobility sector. Referring to the data value chain, data are least valuable in their raw form and most valuable as a service.

Consequently, by selling raw or interpreted datasets, the seller risks giving the data to another actor that can then develop and monetize a service of greater value. The seller would have to assume that the buyer already has a service in mind that he needs the data for. In other words, by selling the datasets he risks only earning a fraction of what he could have made by developing and offering the service himself.

Even though this might not hold true because most services require combinations of various datasets that the original seller is not even able to access, it creates an almost unsolvable psychological barrier. The effect is closely related to the concept of cognitive dissonance or buyer's remorse often experienced in the post-purchase phase of consumer buying processes – in this case applied to the seller.[57] Particularly considering that all actors on the marketplace are private organizations with the

[56] https://www.investopedia.com/terms/f/faang-stocks.asp

[57] https://www.simplypsychology.org/cognitive-dissonance.html ; https://bit.ly/3fyfqHg ; https://www.psychologytoday.com/us/blog/wishful-thoughts/201708/buyer-s-remorse ; https://www.psychologytoday.com/intl/basics/cognitive-dissonance ; https://bit.ly/2CzlFfA

ultimate goal to maximize their profits. Consequently, each seller is highly unlikely to support the development of another actor's service if he sees the slightest chance of developing it himself. By selling the data at the low end of the value chain, the seller would risk merely becoming a component in someone else's offering. Since most large automotive players strive for staking their claim as mobility service providers, their incentive for sharing data with potential competitors is close to zero.

The findings show: the biggest shortcoming is not necessarily the technical implementation, albeit it can be challenging. From our research, the greatest hurdle for mobility data platforms is the underlying concept of monetization and the business model mechanics that create psychological barriers to a prospering exchange.

Simply put – there is a lack of inbuilt incentives in the architecture. Based on the motives and intentions of involved actors, a simple marketplace model does not work well. Competition between participants happens on the platform layer and the service layer, rendering a simple trade market for data very unappealing to involved parties.

The imminent question is: Can new technologies or a different approach to incentivisation help to overcome these barriers and what should a functioning solution look like?

Solution Proposal

Looking at previously identified shortcomings and challenges of existing marketplaces, Distributed Ledger Technologies (DLT) can support an economically viable and accepted solution.

A DLT network can provide a normalized aggregation layer that allows all nested sub-networks of the mobility ecosystem to exchange data without breaking them up - resulting in interoperable access and provenance. All large actors can set up their own infrastructures to manage their data pools so you no longer have one:one access relationships, but automation from network wide permissioning and API calls. An attempt to replace them will create resistance, as networks, platforms and services are already in place and present major switching costs.

Platform Ownership & Monetization

The actual data exchange can be built upon a decentralized network architecture. Thereby, existing networks can transact without a middleman or need for a trusted third party platform, resolving the issue of centralized marketplace platform ownership.

Security, Data Access and Data Quality

The normalization level provides value by securing data ownership and quality, creating trust between parties. It functions as an additional security layer by notarizing and cryptographically securing transactions between actors. Overall network security increases, as each actor secures their own datasets and transactions within their sub-networks without a single point of failure to the overall ecosystem.

Data privacy can be ensured by storing personalized information off-chain. Access management is embedded in key exchanges, limiting access to data to authorized parties and simultaneously signing transactions digitally for full provenance.

If the data notarization process incorporates the original source (e.g. sensor), corrupted datasets can be prevented from entering the marketplace, also rendering the entire data value chain transparent and tamper-proof. A secure audit-trail from raw data to end-user service thus can be created.

Marketplace Dynamics & Data Monetization

The architecture supports prospering competition and market dynamics on the platform level by using a self-regulating system instead of a central control organism. By aggregating individual marketplaces in one shared layer and securing data quality, the architecture allows for fair pricing by enabling transparency. Yet, it still leaves room for individual over-the-counter deal flows.

By integrating the low end of the data value chain as early as data creation at the source, the notarization layer provides a certificate of origin and ownership. Data buyers can be assured that they receive quality data and bad actors on the marketplace can be weeded out based on full provenance.

The proposed architecture also allows a novel monetization design to remove the psychological barriers associated with one-off trades at fixed prices. Using the digital fingerprint of original datasets, suppliers

can be rewarded as contributors based on use. When datasets are used moving up the value chain and a service is built using the provided data, the supplier can participate in the monetization.

New pricing mechanisms can be implemented: Pay-per-use models, real-time bidding or even free sharing, also enabling “product sampling”. Basically, the commercial model of data transaction can be mitigated and aligned with the commercial model of the service/solution using the data. This removes the supplier’s fear of missing out by giving away datasets and supports the idea of an open exchange and data sharing. The data supplier is rewarded for their contribution every time the dataset or final service is used by keeping a share in the datasets. Thus, data is transferred into digital assets.

Both parties benefit from that mechanism. The seller does not risk losing out, the buyer does not risk overpaying for data he cannot use. Data owners can now earn money from data services built on their raw data, even if another company develops the service. This logic creates monetary incentives for all parties involved, facilitates fair trade and encourages data suppliers to share their data with as many parties as possible.

For a successful DLT based mobility marketplace that enables exchange of data on the various layers from raw data to processed, an appropriate network design with a homogenized data frameworks is foundational. For this reason, Constellation Network is engaged with the MOBI Data Marketplace working group (https://dlt.mobi), currently defining required standards and mechanisms for exchanging mobility data. The goal is to propose a working DLT architecture that enables a prospering data exchange in the mobility sector between stakeholders of both private enterprises and public agencies.

Appendix

A more holistic overview of selected industry initiatives and platforms that were reviewed during the creation of this research paper:

Shared Mobility and Mobility Data platforms/solutions:

- https://www.populus.ai/solutions/mobility-manager
- https://www.itdp.org/2017/11/20/smart-mobility-open-data/
- https://transitfeeds.com/
- https://mobilitydata.org/
- https://opentransport.com/
- https://www.omos.io/
- "Digitized mobility – the open mobility platform", which is funded by the German Federal Ministry of Transport and Digital Infrastructure, Fraunhofer FIT is developing, together with many IT system vendors, public transport companies, and the Verband Deutscher Verkehrsunternehmen – VDV e. V. (Association of German Transport Companies) a reference architecture for novel business models for public transport. It is based on open standards and will bring together different regional mobility service providers in an overarching system https://www.fit.fraunhofer.de/en/fb/cscw/projects/digitalisierte-mobilitaet.html
- EY Tesseract
  https://www.ey.com/en_gl/automotive-transportation/tesseract-blockchain-integrated-mobility-platform
- Daimler Platform
  https://www.daimler.com/innovation/blockchain-2.html
- LADOT
  https://ladot.io/
- Municipalities across the country have joined together to create a new global non-profit organization called the Open Mobility Foundation to support the development of open-sourced software that provides scalable mobility solutions for cities:
  https://www.openmobilityfoundation.org/
- MDM
  https://www.mdm-portal.de/?lang=en

Data Monetization Platforms:

- Hewlett Packard Enterprise and Continental:
  https://www.hpe.com/us/en/newsroom/press-release/2019/02/hewlett-packard-enterprise-and-continental-launch-blockchain-based-data-monetization-platform.html

- CARUSO
  https://www.caruso-dataplace.com/

- High Mobility
  https://high-mobility.com/

- Remoto/Bright Box
  https://remoto.com/

- VIN.li
  https://www.vin.li/

- IOTA
  https://data.iota.org/#/

- BMW Connected Data
  https://aos.bmwgroup.com/web/oss/apps/otp-public

- Coord
  https://www.coord.co/

- Otonomo
  https://otonomo.io/

- Geotab
  https://www.geotab.com/

- Fleetonomy
  https://fleetonomy.io/

- V2XNetwork
  https://www.v2x.network/