Available online at www.sciencedirect.com

SciVerse ScienceDirect

00 (2016) 000–000

Transportation Research Procedia

www.elsevier.com/locate/procedia

International Conference on Intelligent Transport Systems in Theory and Practice, mobil.TUM 2017, 4-5 July 2017, Munich, Germany

Personal Mobility Data: Threats and Opportunities

Dominik Huth [a], Anne Faber [a], Florian Matthes [a]

[a]*Technische Universität München, Lehrstuhl für Softwareengineering betrieblicher Informationssysteme, Boltzmannstr. 3, 85748 Garching, Germany*

Abstract

Mobility service platforms provided by companies like Google are as popular as they are convenient to use. Initially offering only basic navigation services, they have evolved to full service market places for mobility. With the rise of these mobility service platforms, the question whether it is a win-win situation must be asked. Possible disadvantages are the exclusion of regional service providers, loss of control and influence over traffic developments for the general public and intransparent terms and conditions, leaving the users unaware of the collection and processing of their data. We motivate the search for alternative, user-centered operating models for an entity that acts as an intermediary between the service providers and its users. Its objective is to provide a comparable service quality while addressing the identified disadvantages. It is necessary to consider an interdisciplinary effort to investigate, among others, legal, technical and social factors.

Peer-review under responsibility of the scientific committee of the International Conference on Intelligent Transport Systems in Theory and Practice.

Keywords: Mobility Data; Personal Data; Data Management

1. Introduction

Current megatrends are posing new challenges to transportation and mobility. Explosive growth of the population is increasing overall mobility demand. Urbanization is taking urban transportation systems to their limits. The aging society introduces new requirements for mobility. Sustainable solutions have to be developed and established as a response to global warming.

At the same time, mobility solutions have advanced considerably. The interconnectedness between mobility users, transportation modes, traffic systems and infrastructure is growing at a rapid pace (cf. Mitchell (2010)) and creates a means to address these challenges. Smart phones and mobile internet connections allow a user to create and adapt individual travel plans instantly in response to changing traffic conditions or personal plans. The paradigm of ”information everywhere” creates new perspectives on mobility: a social and virtual layer is added to the geographical relocation from A to B.

E-mail address: dominik.huth@tum.de

Peer-review under responsibility of the scientific committee of the International Conference on Intelligent Transport Systems in Theory and Practice.

As with all disruptive technological developments, this new situation created opportunities for new companies to enter the mobility market and attack established providers of mobility - public transportation companies, taxis or personal vehicles - and make new markets where the demand was previously unknown or technologically not addressable. The new entrants to the market nearly always win. This phenomenon is known as the *Innovator's Dilemma* (cf. Christensen (2013)).
End users have more flexible options to consume mobility as a service. The market is creating efficient new offers for mobility consumers. New providers have a chance to enter the market and grow to considerable size within a short period of time. Accurate and publicly available traffic information help individuals avoid heavy traffic conditions and optimize private and professional schedules.
But is this a win-win situation? We believe not. In this paper, we analyze the status quo of the mobility market (Section 2) and identify winners and losers. As mobility data is highly sensitive, we survey existing approaches for handling and managing personal data - also outside of the mobility domain - in Section 3. Possible actors and their respective contributions are listed in Section 4. We conclude with a vision for personal data solutions and a call for action and contributions in Section 5.

2. Threats of the Current Mobility Market Developments

The described interconnectedness and the associated progress are transforming the mobility landscape. One noticeable change is the rise of mobility service platforms. A mobility service platform enables the interaction between mobility users and mobility service providers (cf Rochet and Tirole (2006)), facilitating mobility users to consume mobility as a service. The most prominent example of a mobility service platform is Google offering the mapping

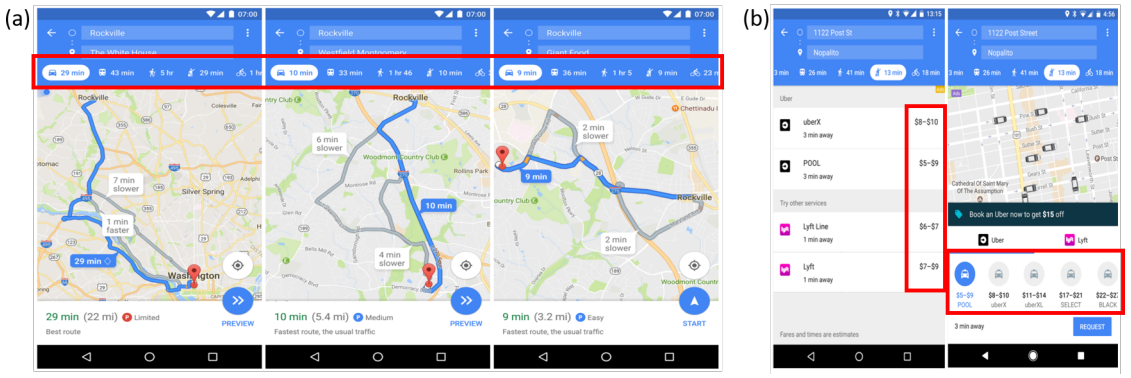

Fig. 1. (a) Google Maps providing different mode of transportation (Buczkowski (2017b)) and (b) Google Maps providing pricing information (Buczkowski (2017a))

mobile application Google Maps[1]. The service, originally providing basic navigation services, evolved to a service marketplace for mobility. When searching for a connection from A to B, the users are offered different modes of transportation, ranging from using the own car or bike, public transportation, car sharing or lately also transportation network companies, also known as ride hailing operators. The different modes of transportation are highlighted in Figure 1 (a). Information is provided regarding the needed time and the associated price (see for example price information for ride hailing operators in highlighted areas in Figure 1 (b)), in case of consuming mobility as a service.
Another development within this connected mobility environment is the emergence of ride hailing services, connecting private drivers and their cars to mobility users looking for private transportation. The most discussed company in this group is Uber[2].
The provider of these mobility service platforms and ride hailing services are in control of the governance of their platforms and can set rules for possible inclusion or non-inclusion of mobility service providers and mobility users.

[1] https://www.google.com/maps
[2] https://www.uber.com/de/

Mobility Service Providers	Companies
Bike Sharing Operators	NextBike[3], Call a Bike [4], metropolraduhr[5], NorisBike[6]
Car Sharing Operators	Car2Go[7], DriveNow[8], Tamyca[9], Flinkster[10], Cambio[11], Greenwheels[12]
Taxi Operators	MyTaxi[13], BetterTaxi[14], IsarFunk[15], BusinessTaxi Munich[16]
Transportation Network Companies	Uber, Lyft[17], Waze Carpool[18]
Public Transportation Agencies	DB[19], MVV[20], MVG[21], VRR[22], AVV[23]

Table 1. Companies offering mobility services

The mobility service platforms, but also the ride hailing operators, are acting as mobility managers.
For both companies – Google and Uber – the individual success story is widely analyzed in research and trade publications (for Google, cf. Beattie (2015), Mourdoukoutas (2011), Hooker (2016), and Uber, cf. Watanabe et al. (2016), Rayle et al. (2016), Haucap et al. (2015), Rogers (2015)). The success is mainly due to a huge number of users. These contribute to the improvement of the service by using it and generating data. An improved service, in turn, attracts additional users, again contributing with their data. In that manner, a data pool is generated which offers a broad range of possible exploitation. As this data pool is owned by the private companies acting as service or service platform providers, the general accessibility is limited. The question which should be asked is if this situation is ideal or rather who is suffering from this development. To answer this question, we analyze the situation in detail for companies offering mobility services, public authorities, and individual mobility consumers.

2.1. Companies Offering Mobility Services

Mobility service providers can be distinguished between classic services, such as taxi and public transportation services, and new, technology-enabled mobility services, especially sharing services, such as car, bike or ride sharing services, but also ride hailing services. In an outcome economy, the result is offered instead of selling the means for obtaining the result, e.g. the bicycle (cf. Grefen (2016)). This demand for mobility as a service is addressed by a large number of companies, as the small excerpt in Table 1 indicates.
The mobility service providers offer their services on own web pages and with mobile applications. As the development and commercialization of mobile application is a common first step of companies to offer digital mobility services, the digital mobility market is fragmented, and the individual user base of each application is limited. Furthermore, some of these mobility service providers are integrated into mobility service platforms. One example is the integration of Uber into Google Maps (see Figure 1 (b)). Companies included in the mobility service platforms benefit from the integration in regards to user reach.
To be included in these platforms they have to adapt to the given conditions of inclusion placed by the mobility service provider. In case of non-integration the companies are facing disadvantages because it is more convenient for mobility users to access only one mobility platform instead of searching manually for mobility service providers online or using various applications. As the starting situation for integration negotiation is unbalanced between smaller and medium-sized local mobility service providers and large globally-operating mobility service platforms, the mobility service providers are only able to choose to integrate their services according to the platform provider's terms and conditions.

2.2. Public Authorities

With the digitalization of mobility, especially in context with autonomous driving and privacy of mobility data, public authorities face enormous pressure to address these topics with new regulations (cf. Schubert (2015), Viereckl et al. (2015), Plucinska and Posaner (2016), West (2016)). Public authorities have the power – by passing laws and regulations – to enable or forestall business models of mobility services and mobility service platforms.
In particular, regulations for ride hailing operators need to be considered, as these services are not yet controlled, compared to taxi operators, and public authorities are responsible for resolving this "gray area" (cf. Watanabe et al. (2016)). Additionally, as presented in a survey-based study by Rayle et al. (2016), ride hailing operators influence the use of public transportation. One-third of the interviewed ride hailing users would have otherwise used bus or rail. This indicates a shift of control from public transportation agencies, which are mainly operated by state institutions or under a particular public contract, towards privately owned companies. In Cohen and Kietzmann (2014) the optimal relationship between mobility service providers, focusing on sharing providers, and the local authorities is addressed to achieve sustainable mobility. After analyzing different business models for car, bike and ride sharing provider, they conclude that a "move toward merit-based business models may offer a more optimal alignment between service provider and local government objectives" (Cohen and Kietzmann (2014), p. 294).
Furthermore, when considering again the mobility data pool generated and owned by private companies, these companies suddenly have greater knowledge about infrastructure usage and citizen behavior than public authorities. The data gathered by public institutions on conventional ways (e.g., capturing license plates of passing cars at two specific points) is quantitatively and qualitatively not comparable to data gathered from individuals, which is also known as crowd sensed data. But to plan public infrastructure according to citizens needs and demands, the quantity and quality of data matters.

2.3. Individual Mobility Consumers

The changes of the mobility landscape are also influencing mobility consumers. By addressing the demand for mobility as a service and the convenience of providing time and price information for various modes of transportation the digital mobility platforms create added value to mobility consumers. The individual search gets obsolete.
But, by using mobility platforms to get navigation information or information of available mobility services mobility consumers are in most cases not monetary charged for accessing this information. Instead, they pay with their personal mobility data. This data - covering information about the exact location and time of a person, but also inferable information about where she lives and works – as these are often visited places at the same time every weekday – and

[3] http://www.nextbike.de/de/
[4] https://www.bahn.de/p/view/service/fahrrad/call_a_bike.shtml
[5] http://www.metropolradruhr.de/de/
[6] http://www.norisbike.de/de/nuernberg/
[7] https://www.car2go.com/DE/de/
[8] https://de.drive-now.com/
[9] https://www.tamyca.de/
[10] https://www.flinkster.de/
[11] https://www.cambio-carsharing.de/
[12] https://www.greenwheels.com/de/
[13] https://de.mytaxi.com/index.html
[14] https://www.bettertaxi.de/
[15] https://www.isarfunk.de/
[16] https://www.businesstaxi-munich.de/index.php
[17] https://www.lyft.com/
[18] https://www.waze.com/de/carpool
[19] http://www.deutschebahn.com/de/start/
[20] http://www.mvv-muenchen.de/
[21] https://www.mvg.de/
[22] http://www.vrr.de/de/
[23] https://www.avv-augsburg.de/fahrplan/fahrplanauskunft

where she spends her free time (cf. Gkoulalas-divanis and Pedreschi (2011)). Facts users are often not aware of. This includes the knowledge about how this private mobility data is further processed, indicating a loss of control.
One example of how this private mobility data can be used to generate profit is location-based advertisement, which is already included in Google Maps (cf. Ramaswamy (2016), Scott (2016)). The application displays nearby special offers and shops according to the user's preferences.
Thus, if mobility users stay unaware of the usage and especially value of their private mobility data they can be considered as losers of the mobility landscape changes.

3. Existing Approaches

As we described in the previous section, the entirely market-oriented development of mobility platforms and mobility data usage led to a situation where there is little control over how data is used and how society and the individual users are affected by these developments. We are convinced that viable platform models have to be investigated that offer alternatives to the strictly business-driven evolution of mobility data usage. Attractive technical solutions have to be developed that offer feasible use-cases *and* responsible data governance. We could not identify work addressing this exact issue, i.e. approaches for managing personal mobility data, but extensive work covers related areas from technological and societal perspectives. We present different efforts from both academia and business.

3.1. Research Approaches

The field of participatory sensing is concerned with the exploitation of mobile phone sensors and the creation of large scale sensor networks (Burke et al. (2006)). However, sensor readings are often annotated with spatiotemporal information and sensitive insights (such as when a person is or, perhaps more importantly, is not at home) can often be inferred from these data points. This motivates extensive research efforts in preserving privacy in such networks. In an extensive study, Christin (2016), collects and categorizes these approaches for preserving privacy in such networks. The author distills six categories, of which two are of particular interest to us: *Reporting* and *Storage and Access Control*. In reporting approaches, the raw sensor data is collected on a server, but obfuscated when accessed. Storage and access control enables the user to define which data is stored and who can access it.
One work that is concerned with access control is PDVloc by Mun et al. (2014). They propose a personal data vault that separates the collection of location data from its transmission. Location data is first sent to a personal cloud service, which shares it according to the specifications (e.g. who is able to see the data and at which granularity level) in Access Control Lists (ACLs) for each application that requests data. A prototype was tested in a field study with 20 participants, after which the participants were interviewed. The authors conclude that the system was perceived as helpful, but in order to increase acceptance improvements on the user interface and the rule recommender were necessary. The research group is also responsible for an initiative called *small data* (see Estrin (2014), Estrin and Juels (2016)), which aims at leveraging individual digital traces to the individual's benefit. A practical area for small data is healthcare, where each individual could benefit from a track record of conditions and treatments.
Most research for privacy preservation covers technical solutions (cf. De Cristofaro and Soriente (2013), Huang et al. (2010), Gao et al. (2013)), but always presumes user acceptance. In their work, Li and Cao (2013) propose two schemes (with and without a trusted third party) for incentivizing data contribution in participatory sensing. Both award credits for task execution, such as reporting temperatures at a particular time and location, while avoiding the risk of exploitation by users. For both schemes, prototypes are built and the power consumption is analyzed, but insights on user acceptance are not given.
An initiative that crosses the boundaries of computer science towards healthcare is midata.coop (Hafen et al. (2014)). The authors motivate their work with inefficient treatment of patients in the health sector, partly caused by insufficient data. Especially in the health sector, strict data protection laws prohibit the usage of such data, e.g. for research or improved treatment. As a solution, they propose a health data store. It is institutionalized by a cooperative, because it is primarily directed at the benefit of its owners. The users could control their own data and decide what should be shared. This shared data would then be exposed by the cooperative in an aggregated way in order to support research

or generate revenue. The project is developing a prototype, which is to be released in the first quarter of 2017[24].
Sriraman et al. (2017) point out that artificial intelligence (AI) is often trained using human input, which is honored with a one-time payment (e.g. via Amazon Mechanical Turk[25]), but the future earnings from that algorithm do not affect their compensation. The authors propose a cooperative for worker ownership of an algorithm, where the workers can give up salary in exchange for shares of the trained algorithm. They conducted experiments that workers were willing to give up 25% in earnings for an investment in the future revenue of an algorithm.
Jentzsch (2016) investigates the economics of personal data from the individual's perspective. The work collects research approaches in personal security economics and identifies five categories within this area: Game-theoretic approaches, experimental and psychological research, victim studies, and two 'other' categories. The author points out that the economics of the privacy market generally don't lead to optimal outcomes in terms of social welfare. A challenge in establishing privacy market mechanisms is the valuation of personal data.

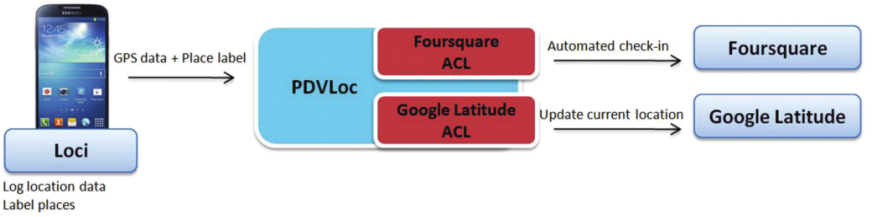

Fig. 2. Conceptual layout of PDVloc prototype (Mun et al. (2014))

3.2. Applied Approaches

The importance of personal data and location data has not only been recognized by academia. With more than $10 million in funding (cf. Crunchbase (2017)) and more than 400.000 users in 140 countries, digi.me (started in 2009 as SocialSafe, rebranded to digi.me in 2014, Ranger (2017)) is probably the most prominent start-up company with a data-centered business model. According to their press information, both the users and the companies face challenges that can be overcome by a safe method for personal data collection. Users lack control or even knowledge of their information that is spread over the web, while businesses are troubled by increasingly inaccurate information about their users. Currently, the solution combines access to different social media accounts. This way, the user can see the information that is shared about her in one place. The company intends to integrate health and financial data in the future and has the long term vision to combine all data about an individual in one place under the control of the individual.
Other tech start-ups companies follow a similar agenda. Emvolution[26] offers a browser plugin that records the user's surfing behavior, which can then be shared to personalize websites and services. Datawallet[27] aims to reimburse users for the data they generate by selling packages of aggregated, anonymized user data. A similar product is offered by Datacoup[28], who allow connecting various social media accounts (Facebook[29], Twitter[30], Linkedin[31]), activity trackers (Fitbit[32]) and even payment information (credit and debit cards) in exchange for a fixed weekly premium of less than $1 for connecting three accounts.
Meeco.me[33] leverages the term small data (see Estrin and Juels (2016) in section 3.2). They intend to collect all data

[24] https://midata.coop/
[25] https://www.mturk.com
[26] emvolution.me
[27] https://datawallet.io/
[28] https://datacoup.com/
[29] https://www.facebook.com/
[30] https://twitter.com/
[31] https://www.linkedin.com/
[32] https://www.fitbit.com/
[33] https://meeco.me/

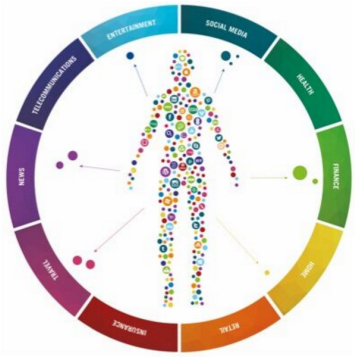

Fig. 3. Digi.me vision (Ranger (2017))

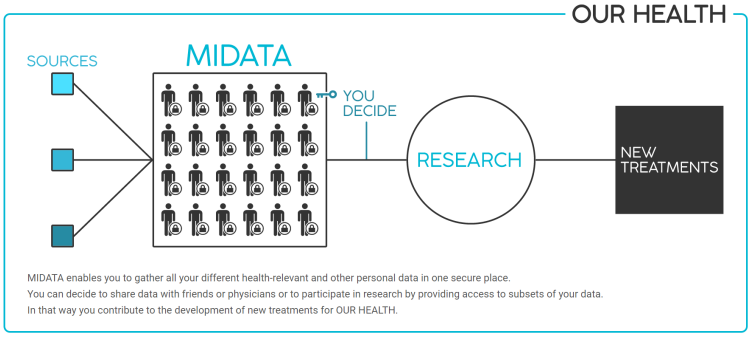

Fig. 4. Midata cooperative for health data

about an individual in one place and offer encrypted cloud storage, a contacts directory, a messaging platform and a web browser with tracking protection. The founders state in their manifesto that they will never mine or sell the data that they are entrusted with. This leaves unanswered how the company intends to create revenue. They lay out a very global vision of a better world through personal data, with impact on the individual, society and even carbon footprints.

Aside from companies that address data privacy and the value of data directly, fitness trackers are also joining the market. Strava, a popular app for cycling and running, is selling aggregated information from bicycle routes for around $0.80 (cf. Farin (2017)) through their service Strava Metro. Several authorities, including the Oregon, Florida and Seattle departments of transportation, are using these insights for more efficient planning of bike lanes.[34] Uber recently announced[35] that it wants to provide free access to anonymized data from over 2 billion trips in order to facilitate traffic planning. Public access is not yet available, so the details have to be discovered in the future.

4. Possible Contributors and their Benefits

We believe that the complex problem of data security cannot be developed in a one-party or one-discipline effort. Multiple groups have to work together in order to obtain a solution that is sustainable and future-oriented, and each group can benefit from these new solutions. In this section we identify who can contribute to new ways of managing and leveraging mobility data and how they can be beneficial.

As a starting point, the sensitivity of society has to be raised. Research in *societal processes* can deliver insights on how the knowledge of motivating citizens to go to vote can be applied in the surrounding of this market vote. As an example, fairtrade labels offer the knowledge that the producers were compensated according to mutually agreed standards. This intangible value is motivating enough to make the sale of fairtrade products a common occurence in grocery store shelves. The mechanisms behind this ”commercialization of moral” (cf. Koos (2016)) and its applicability to data has to be investigated further. Through the support of morally accountable services and initiatives, society can unleash its intrinsic ability for self-improvement.

Computer science has to reach out to other disciplines and incorporate insights about the motivation of citizens in using data-centered applications. Secure solutions are useless if they are not used. We have to build prototypes to discover effective incentives for privacy awareness. Many methods for secure transmission and location obfuscation are already developed, they have to be applied in a non-intrusive and non-obstructive manner. In particular, prototypes have to be built that incorporate the requirements of mobility users and enable sociologists to evaluate their stated requirements against the observed preferences. The situation creates a unique opportunity for computer science to substantiate its self-understanding as a focal area of research and create important links to other research groups, as well as demonstrate its grown importance in society. Efficient algorithms and technologies for managing large scale

[34] http://metro.strava.com/
[35] https://movement.uber.com/

data can be developed and improved with extensive real world input.
Political science can create the guidelines for a long-term vision of how sensitive data can be handled in the future. *Legal science* has to collaborate closely with computer science. An interesting question is how rules and regulations can be molded in software, creating executable privacy as an analogy to executable contracts. Software could track violations and accesses and support transparency of user agreements. Technologists need a better understanding of policies and policymakers need to understand technology better. Regulations are difficult to create, so more thought has to be invested, not less. *Privacy by design*, a guideline established by the former German Federal Commissioner of Data Protection, Peter Schaar (cf. Schaar (2010)), postulates a minimal collection of personal data. Is it realistically possible to reduce the collection of data or should regulation rather adapt to the circumstances that have already evolved? A close collaboration in interdisciplinary teams and the training of individuals with intersecting skills can lead to better regulations and better aligned and more applicable technologies.
Transportation research has to add another justification for these efforts by creating valuable insights and applying them for real-world infrastructure optimization. We believe that this particular area of research can benefit significantly from fair mobility data solutions that contribute data for research. Massive amounts of up-to-date mobility data can be obtained at virtually no extra effort. On-site traffic measurements can become obsolete, allowing researchers to increase their reach to virtually any city and apply methods for planning in more scenarios.
The notion of fair data usage has to spread in *businesses* as well. There are already labels for companies that have clear rules regarding the payment and focus of internships. Could a fair data label be something that a company proudly adds to its communications? New models of sourcing and using data must be thought. Music royalties could provide an analogy for compensating the contribution of data that provides value in the future. An external entity that is trusted by both the users and the participating companies can reduce costs (e.g. by facilitating the acquisition of high-quality, task-specific data) and limit the risk that is associated with storing highly sensitive user data.
Thinking beyond mobility data, other research fields with highly personal data can contribute their domain-specific data models and requirements. As an example, medical research (as already addressed by Hafen et al. (2014)) can define viable formats for collecting health data and share this data with research groups. Especially for rare diseases and conditions, the mere availability of such data can significantly support the development of treatment methods.
As the source of personal data, especially the individual can contribute to the success of alternative ways for collecting and handling data. Through our choices, we decide which solutions grow and where society's attention will be. We can persist on the ownership of our own data and the right to decide how it should be used. The potential benefits are also the greatest for individuals. Alternative data solutions support better policies and applications, they offer digital sovereignty to individuals and support digital democracy.

5. Conclusion

As pictured in this work, the current situation of handling private mobility data is not only unsatisfactory but poses obvious threats especially regarding the usage of private mobility data. Even though approaches are addressing private data issues in other areas, none is considering related, general aspects and includes private mobility data. By involving the previously identified stakeholders the search and realization of a comprehensive solution can be achieved, of which the stakeholder would also benefit.
A possible approach for such an alternative, user-centered entity, could be aligned to existing cooperative models (e.g., the credit cooperatives in the financial sector). The data of each mobility consumer participating would be owned and managed on a common basis. This data could be used – if the individual user agrees – for research purposes, after an appropriated anonymization of the data. The available mobility data could provide more insights on the mobility behavior and influence the planning of public infrastructure, as described in Section 4.
When analyzing the implications of digitization, it becomes obvious that digitized personal data – including financial, health and mobility data, to name just some – are a major factor to be considered. In our view, personal mobility data is a valid starting point to address this.
As the mobility environment is currently reshaping, now is the time to act and consider new and innovative forms of handling private mobility data. The emphasis should be to protect the privacy and meet the requirements of mobility consumers, instead of being solely business driven.
First, the sensitivity of society and individuals has to be raised. This requires creating awareness for the realistic

value of personal data, which includes personal mobility data. The power of one individual in opposing the practices described in Section 2 might be limited, but if more individuals share the same opinion, these limitations can be surpassed.
The research in this area has just started, and we welcome every contribution.

Acknowledgments

This work is part of the TUM Living Lab Connected Mobility (TUM LLCM) project and has been funded by the Bavarian Ministry of Economic Affairs and Media, Energy and Technology (StMWi) through the Center Digitisation.Bavaria, an initiative of the Bavarian State Government.

References

Beattie, A. (2015). The story behind google's success. http://www.investopedia.com/articles/personal-finance/042415/story-behind-googles-success.asp. accessed 03/15/2017.

Buczkowski, A. (2017a). Google maps now lets you order an uber directly in the app. http://geoawesomeness.com/google-maps-now-lets-order-uber-directly-app/. accessed 01/03/2017.

Buczkowski, A. (2017b). Google maps will be soon showing parking availability data. http://geoawesomeness.com/google-maps-will-soon-showing-parking-availability-data/. accessed 02/28/2017.

Burke, J. A., Estrin, D., Hansen, M., Parker, A., Ramanathan, N., Reddy, S., and Al., E. (2006). Participatory sensing. *UC Los Angeles: Center for Embedded Network Sensing*.

Christensen, C. (2013). *The innovator's dilemma: when new technologies cause great firms to fail*. Harvard Business Review Press.

Christin, D. (2016). Privacy in mobile participatory sensing: current trends and future challenges. *Journal of Systems and Software*, 116:57–68.

Cohen, B. and Kietzmann, J. (2014). Ride On! Mobility Business Models for the Sharing Economy. *Organization & Environment*, 27(3):279– 296.

Crunchbase (2017). Digi.me company overview. https://www.crunchbase.com/organization/socialsafe#/entity. accessed 02/28/2017.

De Cristofaro, E. and Soriente, C. (2013). Participatory privacy: Enabling privacy in participatory sensing. *IEEE Network*, 27(1):32–36.

Estrin, D. (2014). Small data, where n= me. *Communications of the ACM*, 57(4):32–34.

Estrin, D. and Juels, A. (2016). Reassembling our digital selves. *Daedalus*, 145(1):43–53.

Farin, T. (2017). Die spuren der touren. http://sz.de/1.3347259. accessed 01/25/2017.

Gao, S., Ma, J., Shi, W., Zhan, G., and Sun, C. (2013). Trpf: A trajectory privacy-preserving framework for participatory sensing. *IEEE Transactions on Information Forensics and Security*, 8(6):874–887.

Gkoulalas-divanis, A. and Pedreschi, D. (2011). Privacy in Mobility Data Mining. *SIGKDD EXPLORATIONS*, 13(1):4–5.

Grefen, P. (2016). The outcome economy. *IRP Magazine 2016: Outcome Economy; Stichting Study Tour Industria*, pages 8–9.

Hafen, E., Kossmann, D., and Brand, A. (2014). Health data cooperatives - Citizen empowerment. *Methods of Information in Medicine*, 53(2):82–86.

Haucap, J., Pavel, F., Aigner, R., Arnold, M., and Hottenrott, M. (2015). Chancen der Digitalisierung auf Märkten für urbane Mobilität: Das Beispiel Uber. *DICE Ordnungspolitische Perspektiven*, 73.

Hooker, L. (2016). Google's two secrets of success. http://www.bbc.com/news/business-35460398. accessed 03/15/2017.

Huang, K. L., Kanhere, S. S., and Hu, W. (2010). Preserving privacy in participatory sensing systems. *Computer Communications*, 33(11):1266–1280.

Jentzsch, N. (2016). State-of-the-art of the economics of cyber-security and privacy. *Browser Download This Paper*.

Koos, S. (2016). Die organisierte Vermarktlichung der Moral und die Moralisierung der Märkte. Eine vergleichende Analyse der Fair-Handelsbewegung und der Entstehung ethischen Konsums in Europa. *Berliner Journal für Soziologie*.

Li, Q. and Cao, G. (2013). Providing privacy-aware incentives for mobile sensing. In *Pervasive Computing and Communications (PerCom), 2013 IEEE International Conference on*, pages 76–84. IEEE.

Mitchell, W. (2010). *Reinventing the automobile : personal urban mobility for the 21st century*. Massachusetts Institute of Technology, Cambridge, Mass.

Mourdoukoutas, P. (2011). Google's two secrets of success. https://www.forbes.com/sites/panosmourdoukoutas/2011/10/13/googles-two-secrets-of-success/#6597b8b9583d. accessed 03/15/2017.

Mun, M. Y., Kim, D. H., Shilton, K., Estrin, D., Hansen, M., and Govindan, R. (2014). PDVLoc: A Personal Data Vault for Controlled Location Data Sharing. *ACM Trans. Sen. Netw.*, 10(4):58:1—-58:29.

Plucinska, J. and Posaner, J. (2016). Self-driving cars hit european speed bump. http://www.politico.eu/article/uber-volvo-self-driving-cars-eu-regulations/. accessed 03/02/2017.

Ramaswamy, S. (2016). Ads and analytics innovations for a mobile-first world. https://adwords.googleblog.com/2016/05/ads-and-analytics-innovations-for-a-mobile-first-world.html. accessed 03/15/2017.

Ranger, J. (2017). digi.me press introduction. https://www.dropbox.com/sh/igulbnf6ipgwxgd/AAC_hcWJtaswPh9rFfI9wwpAa?dl=0&preview=digi.me-press-introduction.pdf. accessed 02/28/2017.

Rayle, L., Dai, D., Chan, N., Cervero, R., and Shaheen, S. (2016). Just a better taxi? A survey-based comparison of taxis, transit, and ridesourcing services in San Francisco. *Transport Policy*, 45(January):168–178.

Rochet, J.-C. and Tirole, J. (2006). Two-Sided Markets : A Progress Report. *RAND Journal of Economics*, 37(3):645–667.

Rogers, B. (2015). The Social Costs of Uber. *The University of Chicago Law Review Dialogue*, 82(85):85–102.

Schaar, P. (2010). Privacy by Design. *Identity in the Information Society - Special Issue*, 3(2):267–274.

Schubert, M. (2015). Self-driving cars hit european speed bump. http://www.genre.com/knowledge/publications/iipc1505-en.html. accessed 03/02/2017.

Scott, W. (2016). Excited about googles new map ads? you should be! http://searchengineland.com/excited-googles-new-map-ads-254629. accessed 03/15/2017.

Sriraman, A., Bragg, J., and Kulkarni, A. (2017). Worker-owned cooperative models for training artificial intelligence. In *Companion of the 2017 ACM Conference on Computer Supported Cooperative Work and Social Computing*, pages 311–314. ACM.

Viereckl, R., Ahlemann, D., Koster, A., and Jursch, S. (2015). Racing ahead with autonomous cars and digital innovation. *Auto Tech Review*, 12(4):18–23.

Watanabe, C., Naveeda, K., and Neittaanmäki, P. (2016). Co-evolution of three mega-trends nurtures un-captured GDP Uber's ride-sharing revolution. *Technology in Society*, pages 1–45.

West, D. (2016). Moving forward: Self-driving vehicles in china, europe, japan, korea, and the united states. https://www.brookings.edu/wp-content/uploads/2016/09/driverless-cars-3-ed.pdf. accessed 03/02/2017.