Review on Mobility as a Service in scientific literature

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Abstract

Our current private car based transport system is inefficient and unsustainable. The Mobility as a Service (MaaS) model is offering a solution by combining public and private transport modes and aiming to provide seamless trips over one interface. This study summarises the current state of the art of MaaS research by analysing scientific research papers. Overall, 16 MaaS-related documents in Scopus and ScienceDirect databases were recognised as relevant for this study. The relevant literature was divided into three groups according to the topics of the studies. The most significant observations are presented based on the literature and future research needs are discussed. Currently, there are relatively few MaaS-related scientific studies published, but the issue is topical as most of the relevant studies were published in 2016 or 2017. This study helps the MaaS stakeholders and the scientific community to recognize the current state of the art and where to focus in future.

1. Introduction

Increasing traffic volumes in cities because of urbanization, the need to decrease greenhouse gas emissions and constantly varying mobility needs call for new solutions for daily transport (El Zarwi et al., 2017). Sustainable transport should be in the centre of the solutions instead of current inefficient transport system, which is based on private cars with underutilized capacity (Strömberg et al., 2016). Everyday traveling from place to another should be possible by integrating flexible mobility options based on current needs. Competitive choices for private cars are called for. The transport system could be seen offering mobility services such in Mobility as a Service (MaaS) paradigm (Melis et al., 2016). In this new paradigm, user's needs are placed in the centre of the transport system.

Hietanen (2014) and MaaS Global (2017) state that Mobility as a Service concept aims to combine different transport modes (e.g. public transport, car-sharing, ride-sharing, taxis and bicycles) to seamless trips over one interface. A MaaS platform covers all necessary mobility operators that are needed to provide flexible and customized transport to different kinds of users (Kamargianni et al., 2016). The main idea is to fulfil mobility needs without need to own a private car or a travel card for public transport (Ambrosino et al., 2016; Giesecke et al., 2016). It is not novel that a journey to the destination can be made by combining different transport modes (e.g. public transport and car-sharing), but according to the new paradigm the whole package can be booked and paid with a mobile application (Hensher, 2017). A service portal forms the wanted trip chain on behalf of a customer and enables the whole trip via single payment or mobility package (Hietanen, 2014; Kamargianni et al., 2016).

The role of cars could change significantly in the new paradigm (Hensher, 2017). When the whole spectrum of mobility options is available via integrated service system, there is a great potential to individual mobility without owning a car. Combined use of public and private transport not only enables smooth mobility options but also provides alternatives

for travelling (Melis et al., 2016; Melis et al., 2017). Decreased level of owning a private car is seen lead to increased use of alternative transport modes, hence raising the popularity of shared mobility services and directing mobility to a more sustainable direction (Giesecke et al, 2016; Karlsson et al., 2016).

In order to provide integrated services, which enhance daily mobility options, real-time data of supply and demand is needed (Melis et al., 2017). Workable mobility services are complex systems as they gather information (e.g. timetables, real-time traffic data, car-sharing availabilities etc.) from various sources (Hilgert et al., 2016). Furthermore, the service platform needs to include all the transport operators in the system. Finally, applicable use of data enables MaaS to combine transport of passengers and goods to the same vehicle (Giesecke et al., 2016).

Disabled passengers' difficulties to use a private car or public transport can be defeated in this new service concept (Atasoy et al., 2015). Particularly ride-sharing and taxi services can be more affordable as a part of the system, which provides better opportunities to individual mobility for disabled people. Generally speaking, conventional public transport cannot provide as good service level as a combination of other transport modes because public transport has fixed schedules and routes (Atasoy et al., 2015). MaaS can make it possible to reach the destination at a better service level (e.g. comfort and travel time), with a more expensive price or at the best possible price, if the service level is not the priority (Melis et al., 2016). Furthermore, customer's need to carry any kind of goods is also considered (Giesecke et al., 2016).

As MaaS is a new paradigm in the transport system, an analysis of MaaS studies is needed to show what the interests and results in the research have been so far. This paper aims to summarise, what is MaaS concept about and what are the key issues in scientific literature on MaaS. The paper answers the questions:

- What has been scientifically published on MaaS so far, by whom, where and when?
- What is the role of different transport modes and services in MaaS?
- What are the key findings and experiences in MaaS pilots and trials?
- What are the effects of MaaS services?

The study is conducted by analysing the articles found in Science Direct and Scopus databases on Mobility as a Service. Reviewing the scientific literature helps the MaaS stakeholders and the scientific community recognize the current state of the art.

The paper is structured as follows: In section 2, research framework and included literature are described. Thereafter three different research issues are discussed and presented in an own section (sections 3, 4, and 5). Finally, section 6 discusses and concludes the main findings.

2. Materials and methods

Analysis in this paper is based on a literature study of peer reviewed scientific articles and conference papers. The search for relevant articles and papers was made in Scopus[1] and ScienceDirect[2] databases in June 2017. In Scopus 37 documents of which 13 were articles and in ScienceDirect 33 of which 22 were articles were found including the expression "Mobility as a Service". Six documents were found in both databases. 16 of the 64 (37 + 33, of which 6 were the same) documents actually were fully MaaS-related. The non-related documents including the statement "Mobility as a Service" discussed for instance mobile networks or MaaS was only a minor part in the study (e.g. only one paragraph included MaaS considerations).

Based on the topics and issues discussed in the articles, the 16 articles were divided into three groups, which are partly overlapping each other. Following the research questions the groups are 1) the roles of different transport modes and services in MaaS, 2) the experiences of MaaS pilots and trials, and 3) the effects of new services. Furthermore, some articles introduce architecture and mathematics behind a mobility application or a scheme, but as this study focuses especially on mobility and transport system issues, these are not analysed in this paper. Many studies discuss a specific transport mode or some modes as a part of the MaaS scheme and thus the first group is justified and needed. The last two groups are somewhat similar. The greatest difference is that the second group describes results of smaller scale MaaS trials and describes some trials whereas the third group discusses the larger impacts MaaS has to the transport system based on enlightened assessments and common observations from trials. It is important to recognise that wide and comprehensive MaaS schemes do not exist yet. The 16 articles and conference papers, in which "Mobility as a Service" was mentioned and MaaS was widely discussed, are presented in table 1 with their main affiliation to the aforementioned groups.

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[1] www.scopus.com (accessed: 14.6.2017)
[2] www.sciencedirect.com (accessed: 14.6.2017)

Table 1. The scientific articles and conferences papers found in Scopus and ScienceDirect in June 2017 with the expression "mobility as a service" and a major MaaS-relevancy. Article group refers to the grouping done for the analysis where 1 = the roles of different transport modes and services in MaaS, 2 = the experiences of MaaS pilots and trials, and 3 = the effects of new services.

Author(s)	Name of publication	County of main author's institute	Publication type	Year of publication	Article group
Ambrosino et al.	Enabling intermodal urban transport through complementary services: From flexible mobility services to the shared use mobility agency: Workshop 4. Developing inter-modal transport systems	Italy	Article	2016	3
Brendel & Mandrella	Information systems in the context of sustainable mobility services: A literature review and directions for future research	Germany	Conference paper	2016	3
Frei et al.	Flexing service schedules: Assessing the potential for demand-adaptive hybrid transit via a stated preference approach	United States	Article	2017	1
Giesecke et al.	Conceptualising mobility as a service	Finland	Conference paper	2016	3
Heikkilä	Reorganization of the mobility service provision - Public governance as a contributor	Finland	Conference paper	2014	3
Hensher	Future bus transport contracts under a mobility as a service (MaaS) regime in the digital age: Are they likely to change?	Australia	Article	2017	1
Kamargianni et al.	A critical review of new mobility services for urban transport	UK	Conference paper	2016	2
Kamau et al.	Demand responsive mobility as a service	Japan	Conference paper	2017	2
Karlsson et al.	Developing the 'service' in mobility as a service: Experiences from a field trial of an innovative travel brokerage.	Sweden	Conference paper	2016	2
Lamotte et al.	On the use of reservation-based autonomous vehicles for demand management	Switzerland	Article	2017	2
Melis et al.	Public transportation, iot, trust and urban habits	Italy	Conference paper	2016	3
Melis et al.	Integrating personalized and accessible itineraries in MaaS ecosystems through microservices	Italy	Article in press	2017	2
Pakush et al.	Using, sharing, and owning smart cars: A future scenario analysis taking general socio-technical trends into account	Germany	Conference paper	2016	1
Rantasila	The impact of mobility as a service concept to land use in Finnish context	Finland	Conference paper	2016	3
Strömberg et al.	Trying on change - Trialability as a change moderator for sustainable travel behaviour	Sweden	Article	2016	2
Thai et al.	Resiliency of mobility-as-a-service systems to denial-of-service attacks	United States	Article	2016	3

The bibliometrics of the 16 publications (presented in Table 1) of which seven are scientific articles (one of them article in press) and nine conference papers were analysed. All of the scientific articles have been published in different journals and hence there is not any specific journal that is more popular than others. As the number of articles is low and they are published in various journals, any specific journal cannot be recognised publishing certain kind of MaaS-studies e.g. according groups used in this paper.

It can be clearly observed that Mobility as a Service is a new approach in scientific literature as 15 of 16 documents have been published in 2016 or 2017. The earliest article recognized for this paper but is not included in the table 1 is Huwer's (2004) study, which did not use MaaS as a term but discussed the role of car-sharing and public transport and effects of their combination. Atasoy et al. (2015) published one of the first scientific MaaS articles although it does not include the term "Mobility as a Service". The article presents a MaaS-

trial, which is discussed at a conceptual level in the article. Before that, Heikkilä (2014) introduced a MaaS concept for the City of Helsinki in her master thesis. Especially thereafter, Finland has had a strong ambition to promote Mobility as a Service.

Most of the scientific articles and conference paper writers have been authors only in one of the publications, which make the author base of MaaS publications broad when considering the number of publications. Only Melis (Melis et al. 2016, 2017) has been the first writer in two articles or conference papers. Furthermore, six writers have been either as a first author or a co-writer in two studies. Analysis on the first writer's organization reveal that MaaS studies are mainly reported by universities. In four publications the main writer's organization is consultant firm, a research centre or municipality. Based on the nationality of first writer's organisation, MaaS seems to have a strong basis in Europe (12 publications) and particularly in Finland and Italy, both with three publications. In two publications the main author's organization is from the USA. Overall, the first writers represent organisations in the developed countries.

Seven of the publications included in this study describe mainly the effects of new services (group 3). Six studies were placed to group 2 and the rest three studies to group 1. Division to the specific groups was made according the main topics of the publications. However, some of the studies include more than one angle to MaaS and thus they could be placed to another group beside of the main group. As a result of low number of publications, valid conclusions about the most popular topics cannot be done, and as new publications are expected, the situation regarding the grouping is expected to evolve.

As many studies have addressed issues similar to MaaS without the term "mobility as a service" in the document, yet these relate to MaaS, other MaaS-related articles were included in the literature review albeit the articles exclude the expression. They were found by using relevant terms e.g. mobility services or car-sharing etc. in databases, but these studies were not systematically analysed as described the 16 MaaS-related studies listed in table 1.

3. The roles of different transport modes and services in MaaS

The current role of different transport modes is expected to change to fit to service-oriented transport system of the future. This section describes MaaS-related changes in different transport modes and services. The section is divided three parts: cars, public transport and cycling. The section "Cars" discusses motor vehicles such privately own cars, car-sharing, car rental, and taxis.

3.1 The role of cars in MaaS

One of the key issues in MaaS is the role of a car. The fundament of new mobility services is the possibility to seamless and reliable mobility without owning a car (Ambrosino et al., 2016). Changes in car ownerships would probably mean more popular times for car-sharing. Car-sharing offers similar options as private cars but without ownership encouraging to try alternative modes, and when car-sharing is one of the alternatives instead of a private car, the actual cost of the trip is easy to compare to other modes (Huwer, 2004). Consequently,

the different transport modes are at the same starting point when owning a car does not distort the choice of transport mode. Successful car-sharing service requires the crowd and is thus the most suitable in high-density urban structure (Giesecke et al., 2016). If there is often heavy goods or many children to carry, owning a car may be a suitable choice, which needs to be considered when service providers and authorities develop new services (Mattioli et al., 2016).

Free-floating car-sharing is a modern model compared to station based car-sharing as free-floating service enables to pick up a car anywhere within operation area as long as the car is free, and to drop off the car within the same area (Becker et al., 2017a). The traditional station based service, in which the beforehand determined starting point and end point for a trip restrict the service, is assessed to affect more towards using sustainable transport modes than free-floating car-sharing (Becker et al., 2017a). Car-sharing in its alternative ways is anyway an important factor in the service concept, but as a separate service it does not provide revolutionary changes (Giesecke et al., 2016).

It is still unclear, who is going to own the cars in the future but someone has to be the owner (Hensher, 2017). Nowadays the majority of the cars are owned by households. Consequently, it seems unlikely or it at least takes several years before owning transfers widely to other actors e.g. car-sharing companies. Car-sharing companies of today may not be capable of owning very large numbers of vehicles, which could be the reason why private persons release their cars to joint use but still own the cars (Hensher, 2017). The quickly developing self-driving cars could change mobility considerably if they are utilized as a service. Pakush et al. (2016) estimated that some of the self-driving cars will be privately owned and rest of them used as a service, and this combination would reduce the amount of cars on roads. Present-day taxi services (e.g. Uber and Lyft) are already part of the transport system's services but their business model may have too little upgrades compared to regular taxis for being a successful member of MaaS (Giesecke et al., 2016).

Decreasing car traffic causes positive impacts to climate and urban space and hence car ownership is an important question (Huwer, 2004). In itself, car-sharing is not more environmentally friendly than any other way of car usage as it also causes congestion but car-sharing companies typically offer newer and smaller cars than taxi services e.g. Uber (Giesecke et al., 2016). However, when cars are not privately owned, there is, supposedly, a bit higher threshold to travel by car than by other transport modes. In service-oriented transport system, driving a car, which can be in the form of car-sharing, can be managed better at the strategic level, which may reduce car traffic (Huwer, 2004).

3.2 The role of public transport in MaaS

The increasing use of private cars has created difficulties to conventional public transport during the recent decades (Ambrosino et al., 2016). At the same time, digitalization has made the use of buses and trains easier as electronic payment, web based route planning and real-time information has been introduced (Melis et al., 2016). However, conventional public transport needs to adapt in the new MaaS model as the current model is not that flexible to offer customer specified mobility, which is the basis of the MaaS model (Hensher,

2017). Reliable car-sharing and on-demand services may decrease the number of passengers in public transport but MaaS can also provide new ways to develop public transport. Fixed-route bus services with high service level are not cost-effective in rural areas, which leads to a lower service level and further lack of passengers (Atasoy et al., 2015). On-demand based MaaS scheme could be capable of providing sustainable transport also to low-density areas.

Typical model with geographic boundaries in producing public transport restricts the flexibility of public transport to act more as point-to-point service (Hensher, 2017). By using smart technology, flexible point-to-point services can be offered by demand-based systems together with conventional services with timetabled routes (Hensher, 2017). As an advantage in flexible public transport, trip's point of origin can act as waiting place and hence there is no need to wait on a bus stop. This may lead to an observation that flexible public transport seems to be more attractive also from car driver's point of view than conventional public transport. (Frei et al., 2017) Adaptation of public transport to the model that fits in MaaS requires more experiences e.g. on how a service-oriented transport system affects people's mobility. Travelling by a privately owned car could be reduced as new services can exploit real-time data on demand, thus produce enhanced service level of public transport and promote connectivity with other modes (Hensher, 2017).

How efficiently public transport can be integrated to other modes, is a crucial question for the future role of public transport. Hensher (2017) presented two scenarios including a combination of bus services and Uber-type point-to-point services, which is a possible scenario for the future as well as the combination of bus services and ride-sharing. Point-to-point services would consist of integration of conventional taxis and public transport. Ride-sharing would instead mean point-via-point-to-point services, which is more like conventional public transport than car traffic but the cost is lower. In ride-sharing, a small bus could replace a car if the amount of passengers is appropriate, but at the same time a fleet of small and large buses would add maintenance cost. It is however unclear, how these kind of solutions would affect the system and how bus contracts (e.g. share of profits) will be organized in MaaS model. (Hensher, 2017)

According to the experiences from Germany and Switzerland, car-sharing acts as a strong supplement for public transport and it also enables giving up car ownership, which further increases the use of public transport (Becker et al., 2017b; Huwer, 2004). Without car-sharing option, public transport oriented lifestyle could be difficult to maintain (Huwer, 2004). Furthermore, residential area's enhanced accessibility has a connection to a decreasing number of privately owned cars and an increasing number of season tickets for public transport (Becker et al., 2017b). Purchasing a car or giving it up reflects a lifestyle change resulting in changes in mobility behavior (Huwer, 2004).

3.3 The role of cycling in MaaS

The discussion about the role of cycling under the MaaS model is missing in almost all MaaS-related literature. It has been mentioned that bikesharing is an important part of a comprehensive service system (e.g. Ambrosino et al., 2016; Kamargianni et al., 2016), but

discussion has focused on other transport modes, especially on private cars, car-sharing, taxis and public transport. Yet, free-floating bike-sharing services offer an easy way to use bikes as the system includes several pick up and drop off points, and because of environmental aspects promoting bike-sharing is worthwhile (Tomaras et al., 2017).

Observations related to bike-sharing systems reveal that bike trips are typically short (usually less than 10 minutes) and this relates especially to most active users (Caulfield et al., 2017; Tomaras et al., 2017). Furthermore, active bike-sharing system next to fixed bus route has been assessed to decrease bus ridership in New York City (Campbell & Brakewood, 2017). However, in these studies bike-sharing has been studied as separate system from MaaS. It would be meaningful to understand the role of bike-sharing compared to expectable cornerstones of service system e.g. car-sharing and ride-sharing services. Current bike-sharing users would be likely users of MaaS as bike-sharing members have been assessed to be more willingness to try new services (e.g. flexible public transport) compared to others (Frei et al., 2017).

It is still unclear what will be the role of cycling as we are lacking proper knowhow of larger scale MaaS schemes. On one hand, bike-sharing services could increase the amount of cycling trips as bike can be chosen for only one part of the trip chain and the bike is easy to access from multiple stations by using credit card or smart phone. On the other hand, car-sharing services offer easy access to automobiles, and ride-sharing services provide lower cost mobility. These are comparable choices for bike-sharing. Ride-sharing and demand responsive transport also offer more applicable pick up points for passengers compared to current public transport, which decrease the walking distances to access these modes. In conclusion, new services promote mobility possibilities in several ways, which make it hard to predict what is the future role of cycling.

4. Experiences of MaaS pilots and trials

This section introduces MaaS pilots and schemes or visions of them. The focus is on describing the experiences and effects of the trials discussed in the analysed literature. As a notable issue, the most advanced MaaS systems are still at a conceptual level or are just being introduced to the markets, making the amount of user experiences still low. Thus, there is not much literature available related to experiences of MaaS implementations, and to support the analysis, different MaaS systems are used as examples of the current state of the practice.

4.1. MaaS schemes

Kamargianni et al. (2016) stated that the highest level of MaaS scheme consists of ticket, payment and ICT integration and also provides mobility packages for customers. Advanced level MaaS systems like Whim, UbiGo, Tuup and SHIFT enable connecting different transport modes to an easy trip chain under a single platform (e.g. mobile app). The systems also allow the customer to plan applicable trip from point-to-point and to pay the whole trip at once or via package. These schemes integrate bike-sharing, car-sharing, car rental, public transport and taxis together. As an advanced system, Tuup's taxi service, Kyyti, consists of on-demand taxis. Kyyti provides regular taxi with normal price but also cheaper shared taxi

services with longer waiting and travel time. (Tuup, 2017) SHIFT also offered one form of on-demand taxis as SHIFT offered cars owned by the company with drivers (Project100, 2017).

Tuup and Whim, which are currently in operation, offer mobility services in Finland. Whim is next expected to expand the services in West Midlands (UK) and Amsterdam (Netherlands) (Whim, 2017). UbiGo had a six months trial in Gothenburg, Sweden, already in 2013 and second version of the trial is expected to run in other cities (UbiGo, 2017). SHIFT was introduced in Las Vegas in 2013 but the service has been discontinued (Project100, 2017).

Kamargianni et al. (2016) assembled different MaaS schemes world widely and created an index, which set up schemes based on the integration level (ticket, payment, ICT and mobility package integration). According the index, the higher the integration level and the higher number of transport modes included in the scheme, the higher is the level of the MaaS scheme. The study found 15 MaaS schemes and most of them got a comparably high score. In this index the so called Helsinki Model, a vision for the future, that Heikkilä (2014) presented, got the highest score. UbiGo and SHIFT were among the best in this comparison. Whim and Tuup were not included in the study, as they were not established at the time of the comparison but would presumably been ranked high.

Several other MaaS-related systems or applications have been created but they do not integrate the main transport modes to one system or the most critical integration (e.g. ticket and payment) is lacking and thus the system is incomplete. A crucial part of future's customized mobility options is demand responsive transport (DRT), which is already a part of Tuup's application. Kamau et al. (2017) created Demand Responsive Mobility as a Service (DRMaaS) that is a transport service between taxi and bus services. DRMaaS was tested in Dhaka, Bangladesh, which indicated reduction in waiting time, and travel time was on average almost the same as by bus. The cost was more expensive than travelling by a bus but clearly more inexpensive than by other modes. Atasoy et al. (2015) developed simulation trial called Flexible Mobility on Demand (FMOD) service, which provide customized service to end-users, but the service system is not comprehensive as it solely consist of taxi, shared-taxi and minibus services. Flexible on demand transport called Kutsuplus was tested in Helsinki, Finland from 2012 until the end of 2015 (HSL, 2017). Even though ride-sharing minibus service Kutsuplus ended because of financial issues and scalability problems, the trial presented great potential for such a service (HSL, 2017).

One of the purposes of MaaS platforms is to make it easier to manage everyday travelling as our transport system with multiple mobility options is somewhat complicated (Hilgert et al., 2016). An example of that kind of a platform is a personal mobility assistance described by Hilgert et al. (2016). Furthermore, service platforms benefit service providers by enabling them to integrate needed external component (e.g. a bus tracking service) to the existing system, which could already include e.g. timetable services (Melis et al., 2017). A marketplace for mobility services called Smart Mobility for All (SMAll) introduced by Melis et al. (2017) is capable to integrate different data sources e.g. real-time transport data and pricing to enable trip planning for end-users and monitoring tool for authorities. The formation of a comprehensive service concept supports traveller's daily mobility in the

terms of starting and ending time information of the trip with appropriate cost and travel time combined to intelligent ways to share information between transport operators.

4.2. Experiences of MaaS trials

As the current amount of comprehensive MaaS-schemes is low and some of them are newly established, there is not much data related to user experiences. UbiGo's trial is one of the few high-level schemes that has published questionnaire data on participants' experiences. Survey data of 151 users of the UbiGo pilot revealed that the participants increased their use of car-sharing and public transport while decreased their use of private cars during the trial. The trial integrated several transport modes under one payment package. An interesting detail is that customers overestimated their need to use car-sharing service as they purchased more car hours than they used during the trial. This could be a result of changing car trips to other transport modes. (Karlsson et al., 2016)

Almost all of the participants would have been interested in carrying on using UbiGo after the end of the pilot. It was mentioned that the service, which was used through mobile app, caused problems to some customers and thus help desk via telephone and even special guidance meetings were worth to be arranged. To sum up, users became more negative towards private cars and more positive towards alternative modes due to UbiGo trial. (Karlsson et al., 2016)

MaaS enhances user acceptance compared to time before the services. Without a MaaS bundle, the availability of various mobility options and flexible working conditions cause difficulties to chooce a trip chain (Hilgert et al., 2016). Particularly "high-level" MaaS schemes with multiple modes and integration of necessarily attributes are expected to increase the demand for the new service concepts (Kamargianni et al., 2016). A key issue is to manage user's travel behaviour in a better way with these new tools (Hilgert et al., 2016).

Mobility trials can have an enormous role in changing people's mobility patterns. Even though a person may have an intention to change one's mobility behaviour to a more sustainable direction, it is, however, difficult to evaluate actual results of the change to personal life and this is why trials enable a safe way to try new modes (Strömberg et al., 2016). Especially, to give up owning a car and to adopt new mobility services causes hesitation and consequently mobility habits could remain as before. The trials have indicated that people's preconceptions have altered after the trial but it is important that duration of the trial is long enough (e.g. six months) in order to change mobility behaviour (Strömberg et al., 2016). Mobility service apps can also suggest to add sustainable behaviour (e.g. walking and cycling) to trip chains and thus encourage people to a healthier lifestyle (Melis et al., 2016). Apps and trials could have even a larger impact if they are considered as a strategic tool to modify everyday mobility (Strömberg et al., 2016).

The trials are an important step to change the paradigm but they also reveal challenges related to the MaaS system. First of all, careful planning is required to combine different services and transport modes offered by different operators into one MaaS scheme (Kamargianni et al., 2016). Furthermore, the end of the trial should not be the end of the MaaS scheme as long as user experiences have been positive (Karlsson et al., 2016). As

public transport, which could be subsidised by taxes such in case of UbiGo, plays a crucial role in MaaS, support from policymakers is needed to ensure enough funding and necessary regulations for a permanent system (Karlsson et al., 2016).

As MaaS should be able to compete with the current car-based system, it is important to develop the quality of the MaaS scheme enough before beginning to operate. International standardization of data-formats and APIs (application programming interfaces) is also required in order to provide technical possibilities (e.g. integrated services) for the background system of MaaS (Melis et al., 2017). Expansion of the business to other countries is another challenge but internationalisation is more likely to happen after successful implementation in one country.

5. Effects of new services

Changes towards a service-oriented system have an impact to the whole transport system and the users utilizing it. As MaaS system is not yet widely and consistently adopted anywhere, the impacts described in this section are based on observations of smaller projects and enlightened assessment. In the new paradigm, future transport system is created in a smarter way than by building new capacity and the convenience of a private car can be maintained without the burden of ownership (Hietanen, 2014). MaaS seems to be a desired model from society's point of view as it offers more efficient use of transport modes and their combinations mean more efficient use of the infrastructure, which further promotes cost-efficiency of investments already done (Rantasila, 2016). Furthermore, the possibility to combine travellers' needs and to supply public transport services more cost-effectively may reduce the demand for public subsidy to public transport (Hensher, 2017).

In order to get people change their current role from transport providers (driving a car from point-to-point) to customers (using mobility services), MaaS is required to be capable to fulfill the daily mobility needs. Actually current transport systems is already providing options to different needs since public transport is appropriate for many daily trips, taxis and bicycles provide flexibility to more specific individual needs, and car rental and sharing services cover the rest of the mobility needs (Huwer, 2004). Service-oriented system combines these different modes and services on behalf of the customer e.g. by creating instructions on what to do to reach the desired destination and thus different mobility options are becoming easier to use. As added value of MaaS, trips are planned by a digital app (Hensher, 2017).

Anticipation for the development of the transport system is challenging as we can solely estimate how the novel technologies and social behaviour e.g. autonomous vehicles, car-sharing, ride-sharing etc. will affect mobility (El Zarwi et al., 2017). Despite the recent hype related to e.g. autonomous vehicles, we have not that much understanding, whether people are going to adopt and utilize these vehicles in larger scale. El Zarwi et al. (2017) presented a prediction model for the new technology adoption. According the model, one example of a successful way to find customers for car-sharing, which is expected to be in an important role in MaaS, is to set a car-sharing station next to a larger technology company. Furthermore, men and high-income groups were estimated to have a positive attitude

towards new technology. These findings provide valuable knowledge on the things that are useful to consider when acting as a service provider or running the whole service system.

The most evident change because of MaaS seems to be in the role of car as Hensher (2017) stated based on previous literature. Changes in car ownership could, for example, mean a reduced demand of parking space, which enables new possibilities for land use, and particularly creates space for something else (Rantasila, 2016). However, it is not fully clear that change in car ownership would mean less demand for car parks and decreased level of congestion. As a consequence of MaaS, more efficient use of existing vehicles would decrease the traffic volume, but better services for individual mobility (e.g. for disabled people) could mean increased traffic and eventually more congestion than in the current system (Rantasila, 2016). Since only a few studies related to intelligent mobility services have focused on environmental impacts, the sustainability of MaaS requires more research (Brendel & Mandrella, 2016).

Ownership itself is not the difference maker in the terms of popularity of car travelling if the car-sharing and taxis are easy and affordable choices compared to others. However, the use of sustainable modes could increase in principle, when a private car is not all the time ready to depart right at the forecourt. When people are not "forced" to use car, they can better choose the transport mode that fits their individual requirements (Karlsson et al., 2016). If people choose to replace conventional timetabled public transport services during peak hours with a flexible car-sharing services, congestion is still likely to remain (Hensher, 2017).

In order to work properly, the service-oriented transport system demands actions from the public administration. It should be ensured that the roles, responsibilities and collaboration regarding mobility operators and institutes that are in charge of the whole system are appropriate from mobility services point of view. The public administration itself could act as an upper level organizer and thus would be responsible of the collaboration of operators or the role of central MaaS operator could be given to private companies (Melis et al., 2016). Anyway, as public transport is expected to play a key role in the new paradigm, the public transport authorities are key stakeholders as a one of the upper level MaaS organizers (Ambrosino et al., 2016).

As individual mobility data becomes an integral part of service development and daily transport, information security and privacy are increasingly important factors to recognise. Melis et al. (2016) state that the privacy of customers should be secured more reliably when the service system is led by public administration, while private companies in charge could lead to uncertainty in data collection and its usage, even though market-based mobility services also create benefits. Another information security aspect is Denial-of-Service attacks, which would affect the society widely if mobility is increasingly dependent on data systems (Thai et al., 2016). Moving towards self-driving cars would even emphasize this aspect, when abusers could affect the safety and road traffic.

6. Discussion and conclusions

Based on the literature review Mobility as a Service could be defined as a concept in which individual mobility needs can be fulfilled effectively and more sustainably than currently by integrating different transport modes and services to seamless journeys. This requires an open platform for cooperation of various mobility operators. If regulation of transport will be updated to meet operating conditions of MaaS, service supply is expected to expand considerably (Hensher, 2017). As a new approach to mobility, service-oriented transport system demands adjustment from users, operators and public administration.

Applicable and sustainable MaaS system requires well-planned functions and also a strong support from policy-makers and other stakeholders. Kamargianni et al. (2016) stated that integration of ICT systems, ticket and payment system, and pre-pay option are prerequisites for a successful MaaS implementation. This means that one ticket or smart card has to be applicable in every transport mode and there could be a possibility to buy a specific amount of time or distance of mobility services in advance (Kamargianni et al., 2016). Bookable on-demand services (e.g. shared-taxi), which are a part of the comprehensive MaaS concept, include inconveniences compared to private cars, which is a reason why MaaS needs to offer other benefits like avoiding congestion because of appropriate start time giving by the booking system (Lamotte et al., 2017). The new concept should not only include existing transport modes but also offer better circumstances (e.g. better service level or lower costs) simultaneously (Giesecke et al., 2016).

MaaS is a new concept and the amount of MaaS-related scientific articles is currently low. However, it is a hot topic as most of the MaaS studies were published in 2016 or 2017. Taking into consideration the relatively low amount of articles and papers, all the recognized scientific publications could be analysed in this study. Currently, in 2017, we can identify the early stages and ideas of a Mobility as a Service. Based on the literature, MaaS is identified and estimated to have wider scale impacts on mobility and transport system such as:

- Services make transport system more efficient and help to recognise and choose daily mobility options
- Personalized services enable seamless trip chains by integrating different transport modes
- Popularity of the private cars is expected to reduce as flexible choices such as car-sharing and on-demand ride-sharing services become more common
- Currently the actual cost of car travelling is difficult to determine but mobility services, including car-sharing, simplify cost comparison of different transport modes
- Sustainable transport modes are expected to become more popular albeit there is not much discussion of the role of cycling in the MaaS literature
- New flexible transport modes force conventional public transport to adapt to a more service-oriented system
- MaaS trials enable great possibilities to get to know and try out the new mobility services
- Public sector has a key role as an enabler of MaaS e.g. by supportive legislation.

In this study, current state-of-the-art MaaS-research was assorted to three groups. As MaaS consists of various transport modes, it is natural that in many articles the discussion is done from point of view of specific transport modes and services. Particularly, the role of cars, including e.g. car-sharing, is discussed widely. The role of conventional public transport and its integration to new services are also covered in many ways. Several studies also describe MaaS as a concept and try to explain its meaning. In the future, society, land use and transport system points of view would be important to cover more thoroughly in order to understand the comprehensive impacts caused by the different sub-impacts, e.g. the integrated effects of transport modes. As another aspect to expect integrated research on is how highly automated and self-driving cars will affect MaaS and connect to it and further to the whole transport system.

In conclusion, the scientific community has quite little knowledge about actual effects following from MaaS because first large-scale implementations are about to start in 2017. As the next step there is a need to analyse mobility data provided by private companies or in some cases public administration, to study the new paradigm more deeply. That may be a challenge as private companies' willingness to share the data is not clear. As Giesecke et al. (2016) stated, we also need research about the roles and responsibilities of MaaS stakeholders currently and in the future. Furthermore, more sustainable transport is one of the possible outcomes of MaaS, but researchers need more knowledge on why users decide to choose more sustainable mobility (Brendel & Mandrella, 2016). As new transport modes (e.g. car-sharing and ride-sharing) become more popular these modes should be included in travel surveys in order to get more detailed data of their use (Frei et al., 2017).

Today, travelling by a private car is a significant issue in our transport system. MaaS concept, however, aims to change that pattern by encouraging to use mobility services. It is interesting to see if the desired service-oriented system is tempting enough to make people change their mobility patterns and give up private cars. All in all, the role of ownership and motoring under MaaS is an interesting and justified topic for future research. Households, which do not own cars or with several people but one car, have probably the highest interest towards MaaS at the early stages of implementation. The role of cycling in service-oriented system is another topic, which should be covered more widely. As a MaaS has the potential to change mobility patterns notably, it will be an interesting topic for further research and scientific publishing.

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