MOBILITY-AS-A-SERVICE – A CHALLENGE FOR IT IN THE AGE OF SHARING ECONOMY

AGNIESZKA SZMELTER

Department of Logistics, University of Gdańsk (UG)

Generation change contributes to the emergence of new consumer trends, defined by global economy researchers as medium-term trends. One of them is the modification of the existing traditional model of ownership and use of cars. The sharing economy is based on the sharing of resources (e.g. cars) by owners to external entities or individual users. Mobility-as-a-Service has become the answer to new mobility needs. In the future, its development will affect the creation of new business models, both by existing and new market players, not only from the automotive industry but also IT sector, especially its part dealing with the creation of mobile applications. This paper presents MaaS characteristics and the use of this kind of services in mobility in the city.

Keywords: automotive, logistics, mobility, city, IT, information logistics, ICT, MaaS, Mobility-as-a-Service, car sharing, ride splitting, e-hailing, urban transport, sharing economy, mobile applications

1. Introduction

Changes in the mobility of people, caused by growing tendency to change jobs, increased interest in travel, improved access to modern technology, and finally - the development of technology in the automotive industry, have created new challenges for the IT sector. Shortening product lifecycle in the innovative economy sectors has led to a decrease in interest in the purchase of their products by users because they do not have money to change them frequently. The emergence

of sharing economy idea has changed the current approach to property ownership, today usually defined as a "traditional ownership model" for a new approach based on making available assets available to generate additional income or access to other previously unachievable assets.

This paper aims to achieve the cognitive objective, which is to present the group of new mobility services, in fact – a part of it which is MaaS group and state-of-the-art about them. The main research questions in this paper are:

RQ1: What makes MaaS services competitive in the era sharing economy?

RQ2: What are challenges (also for IT) related to the development of these services?

The article is organized as follows. The first part concerns few areas having an impact on MaaS emergence and development, which are: generational change, sharing economy and mobility changes. The next one presents the method chosen for carrying out scientific research. The following chapter mentions research results. The end of the article includes conclusions, research limitations and further research plans and guidelines.

2. Main determinants of the emergence and development of MaaS

2.1. Generational change

Social trends strongly influence the world economy [28]. Fashionable among the researchers has become the separation of individual generations and their characteristics, which describe the professional and family life of particular age groups. Derivatives of these qualities have become models of lifestyle, which are elements of mobility patterns [28]. Generally speaking, these generations were originally defined by labor market researchers, e.g, the Traditionalists (born 1922-1945), Baby Boomers (born 1945-64), X (born 1965-1980), Y (born 1981-1999), Z (born in 2000 and later).

One of these megatrends described by the researchers is "silver revolution" and the dominance of the Y generation in the global economy. The first one concerns a growing role of people aged 50 and more in the development of social, political and economic life. This is due, among other things, the aging of societies, especially in countries with mature economies. The remaining megatrends are related to the dominant generation of young people developing their professional career. In a few or more years, the generation will enter into the best productive period in their lives, defined as the age of 35 to 44 years.

It is also important to highlight in the context of this article that older generations cannot keep up with technological change in the current digital economy as quickly as younger ones, although there are significant differences between the representatives of these generations in different world regions. However, even if

they are familiar with new technologies, the learning process in the case of new solutions is much longer in their case than in the case of younger generations, especially Y and Z, and that is why they are the main target group for IT providers offering new IT solutions. The same situation takes place in relation to new mobility services.

2.2. Sharing economy

Generation differences are also evident in the possession of various items or the purchase of technology-related services (e.g. mobile phones, computers, mobile devices, etc.), including cars. The definition of ownership and use is changing - buying or leasing will involve not one car but the whole "garage" of vehicles. Carmakers begin to introduce a monthly fee instead of a one-time purchase, or a small number of installments, like it is popular in the case of cheaper products such as cell phones. So customers can choose a car from a wide range of available vehicles. As a result, lifestyle associated with the use of the car is changing - a different kind of car will be used by users on weekdays, another - during weekends and holidays. As a result of many urban changes, the future consumer will pay less attention to price, brand and reliability, but more to environmental issues, operation costs, safety, car personalization, congestion and alternative transport modes. In addition, car sharing will be offered also by individual owners, not only business units. There will also be different types of offers: car rental for minutes, subscription rates etc. This is a result of the sharing economy development.

Sharing the resources has several key features that enhance its advantages over the traditional model of ownership. First, it allows the use of assets when they are needed, without the need for maintenance (e.g. the purchase of insurance, cleaning, periodic technical inspection, repairing), what consumes a lot of time, so valuable in today's society, focused on their passions and personal development. Secondly, the average consumer can afford to use a resource that is more expensive than if he had to buy it. Thirdly, he can change this resource from time to time by changing, for example, a service provider. Fourthly, consumers wanting to use new, up-to-date, most innovative assets, such as cars, do not need to invest in their purchase, especially today, when technology development is very fast. So they can always rent resources with the highest technical level.

2.3. Mobility changes

In the era of the development of the Internet of Things (many say about the Internet of Everything), mobility will be one of the key elements of human life, both in rural and urban areas although it is more visible in the city than in the countryside. Congestion and parking space problems are there serious and that is why residents will look for new solutions to maintain the level of independence in mobility and not give up comfort. It will be one (apart from growing role of teleworking,

generational changes and sharing economy) of the most significant causes of using new mobility services including MaaS solutions.

Mobility changes will emerge as a result of the previously mentioned generational change, especially changing dominant lifestyles of city and countryside residents. As it was said, there are few generations which will have an impact on future mobility. They represent different attitudes in mobility, attachment to the car as a means of transport, tendency to use intermodal transport, ability to give up comfort etc. This is an area of multiple research in sociology, geography, and economics. But one thing is clear: this generational change mixed with developing sharing economy and mobility changes in today's digital economy will have an impact on the development of new solutions [28], and their aim will be satisfying the needs of consumers with a different age. What is more, it will be an answer for needs related to social exclusion, because still the car is seen as a symbol of status [25].

3. Research method

The main goal of this research is to present MaaS solutions and that is why, because it is a basic research, literature review procedure of a research review of Denyer, Tranfield [5] (see Table 1) was chosen as, in the opinion of Author, the best one to achieve the mentioned goal. This procedure is used to explain phenomena, mostly in socio-economic research areas. It allows for state-of-the-art analysis and identification of potential research gaps. This standardized research procedure makes research in this paper transparent, replicable, exclusive, aggregative and heuristic. It was qualitative research, that is why its results are presented as a descriptive report in Research results section.

Firstly, 9 literature search engines were chosen according to their range and scope (BazEkon, DOAJ, EBSCOhost, EMERALD, JSTOR, ScienceDirect, Springer, Web of Science, Wiley Online Library). The analysis included the EBSCOhost search engine, and therefore the databases that are included in it (HighWire Press, Hospitality&Tourism Complete, Master File Premier) were omitted. After this step, the Boolean Logic was used to identify the literature to further analysis. The first inclusion criteria were:

- "mobility" in title, abstract or keyword, than
- English as a publication language,
- "maas" or "mobility-as-a-service" in the text,
- full-text records for reviewed articles,
- publication year: from 2010 and area: management, economics, geography.

Table 1. Research procedure

Phase	Stage
I	1. Determining the study purpose
II	1. Determining basic literature
	2. Selection of publications
	3. Preparing publications database
III	1. Bibliometric analysis
	2. Content (text) analysis
IV	1. Preparing a report (research results)

The next step in the procedure was to verify titles and keywords. Among the other topics excluded in the study at this stage were the mobility of workforce in different countries, mobility of people with disabilities, software development (general), distance education and the use of virtual libraries, the provision of local services based on current user location, distance work (mobile work). Then duplicated records were eliminated and the Author obtained 137 articles for abstract review. 26 articles about MaaS were selected, and finally, after content analysis, the Author has chosen only these about MaaS related to car use (14 papers).

In the paper were discussed only issues related to MaaS services connected with the car use. So the content of extracted papers was analyzed in order to research findings related to MaaS car services. Of course, there are also solutions related to public transport mentioned in studies of Chong et al. [3], Cronckleton [4], Guo et al. [9], Hennessey [10], Kim & Schonfeld [18,19], Liang et al. [22]. In this article, only monomodal mobility services were taken into account in order to describe two areas to address research questions: 1) characteristics and examples of MaaS solutions (related to RQ1), and 2) elements/functionalities of MaaS solutions (related to RQ2).

4. MaaS (Mobility-as-a-Service) – research results

Mobility Services are a set of traditional and new solutions offered to customers in order to realize their trip. New Mobility Services is a group of products that have recently emerged as a result of changing socio-economic trends. These include the sharing economy, of which a derivative is a shared mobility. There is a discussion in the literature about whether NMS has the same scope as MaaS or not, and there are other names for the same solutions, such as Shared Mobility Services [15], Mobility-on-Demand [3]. In this paper, it was assumed that Mobility-as-a-Service group is a part of NMS. They can be delivered both by private car owners

(C2C) and by business fleet owners (B2C, B2B, B2A) and with use of web portals or mobile applications.

New forms of inter-sectoral and intra-sector cooperation will result in emerging of new business models. They include the following: Product Focused Manufacturer (PFM, today existing model, 35% share in the mobility market in 2020), Service Focused Manufacturer (SFM, existing today, 44%), Basic Mobility Provider (BMP, new model, 11%), Mobility Service Provider (MSP, new model, 10%) [32]. Bidders will have to face up to the creation of several business models at a time, depending on the market. These services are supported on a virtual network by MMPs (multimodal mobility platforms) what allow planning and realization of travel by use of various means of transport.

Mobility as a Service is, according to various sources, related to Logistic 4.0 or Mobility 4.0 [28]. It involves renting a vehicle from the owner in order to travel on a given route. If this would be strengthened by the development of autonomous vehicles, this would be a revolution in the global market. This would fit both into the lifestyle of successive generations and the ubiquitous trends of life digitization and convergence (including media and technology).

This concept is already being implemented today, mainly through mobile applications and online services offering travel sharing and route optimization, using one or more transport sectors. There is also a wide range of kinds of MaaS services related to car use (see their characteristics in Table 2). KPMG predicts that in Trinidad in 2029, 25% of large city residents will use daily solutions to optimize the city's routes by using car rentals and other means of transport [20].

M. Kamargianni et al. [15] defined three main integration types which should be defined for every MaaS solution: ticket&payment integration, mobility packages (mobility services integration) and ICT integration (see Table 3). Ticket integration relates to using one smart card or ticket to get access to different services. Then, one account is charged for the use of chosen solutions. Mobility packages include the possibility of pre-paying for a specific amount of the same or different services in one package, measured by travel time or distance. ICT integration means the chance to get access to information about different modes of transport or different providers. All these three areas of integration can have various potential and integration level – a partial integration of ticket&payment and ICT, an advanced integration of ticket&payment and ICT but without mobility packages and an advanced with mobility packages. Characteristics of them and examples are presented in Table 3.

Table 2. Characteristics of MaaS services related to car use

Type	Model and year of first offer	Description	T*	F*	D*	Examples
Traditional	Car rentals (ca. 1900)	Renting a car for predetermined number of days	D	H	L	Many
	Taxis (ca. 1910)	Point-to-point transport of passengers	M	M	S,M	Many
	Carpooling/ carsharing (1948)	Transport of riders by non-professional driver based on fixed schedule departure and close destinations of co-riders	M,H	M	M,L	Zipcar, car2go, , Go Get, Car2Go, RODA RIO, eHi, BlueLy, Multicity, e-Flinkster, Zoom, GoCar, enjoy, City Car, Carrot, Cityhop, Zipcar, Drive Now, Open Mobility, Olympus, Street Life
	Microtransit (1990)	Transport of riders by small busses according to schedule or on demand	M,H	M	S,M	Bridj (Boston, Washington, and Kansas City), Chariot (San Francisco), Via (New York, Chicago), Leap Transit (San Francisco), Kutsuplus (Finland)
New	E-hailing (liftsharing) (2010)	On-demand hiring a private car by a group of riders (using an application and an electronic device)	M	H	S,M	Uber (global), Lyft (United States), Didi (China), Ola (India), Haxi (Europe), Gett (Europe)
	Ride splitting (2014)	On demand hiring a private car (using an application and an electronic device), but the driver is like a taxi driver	M,H	H	S,M	UberPOOL and UberHop, Lyft and LyftLine
	Shared e-hailing (2015)	On-demand hiring of a shared-occupancy car by multiple drivers (using an application and an electronic device)	M	H	S,M	Uber (global), Lyft (United States), Didi (China), Ola (India), Haxi (Europe), Gett (Europe)
	B2C Car sharing,(2013)	On-demand short-term car rentals from its owner (fleet operator)	M,H	M	S,M	Zipcar, car2go, and Enterprise CarShare in USA
	C2C Car rental (2015)	On-demand short-term car rentals from its owner (individual owner) using an application, website and electronic device	H,D	L,M	S,M	Zipcar, car2go, and Enterprise CarShare in USA
	Carpooling 2.0 (2005)	Carpooling with the use of a virtual application and an electronic device	M	M	S,M,L	BlaBlaCar (Europe), Flinc (Europe, South Africa), vRide, Commutr, Waze (USA), RezoPouce (France), GetAround (San Francisco), Drivy (Paris), Turo (San Francisco)
	Taxi 2.0 (2005)	Ordering a taxi with the use of a virtual application and an electronic device	M	M	S,M	EcoCar (Polska), mytaxi, iTaxi, Cab4You (Europa), Curb, TaxiDiamond (USA)

*T-time: M-minutes, H-hours, D-days; F – flexibility: H-high, M-medium, L-low; D-Distance: L-long; M-medium; S-short.

Table 3. Types of integration in MaaS solutions

Type of integration	Description	Examples
Partial integration	The basic level of integration Transport modes are integrated in a way that travelers cannot exploit the full benefit of mobility potential	Cambio (Brussels, Belgium) Switchh (Hamburg, Germany) Qixxit, Moovel (whole Germany)
Advanced integration	The level that most of the MaaS schemes belong to Its core is the advanced integration of public transport, car sharing, and taxi, but also has cooperative relationship with long-distance rail and car rental operators	Hannovermobil (Hannover, Germany) EMMA (Montpelier, France) Smile (Vienna, Austria) Optimod' Lyon (Lyon, France) BeMobility (Berlin, Germany)
Advanced integration with mobility packages	An extension of the previous group Offers of pre-purchasable and pre-constructed mobility packages, also on-demand Packages are related to a specific socio-demographic group (families, commuters, businesses)	Hannovermobil 2.0 (Hannover, Germany) BeMobility 2.0 (Berlin, Germany) SHIFT (Las Vegas, USA) UbiGo (Gothenburg, Sweden) Helsinki Model (Helsinki, Finnland)

All previously mentioned characteristics of global economic changes and mobility solutions had to lead to making characteristics of MaaS solutions. As a result of the literature analysis, elements of such software were distinguished, which in some sources were called functionalities. Accordingly, they are presented in one column in Table 4. These functionalities were divided into 4 groups according to Bouwman et al. [2], who identified in their paper 4 areas of software design: design of the service (most important for value creation), technology design, organization design and finance design (see Table 4). Service design is responsible for value creation process, making IT solution attractive to customers, users, and contains a lot of functionalities related to use of web portal or mobile application by users. This is a group of elements connected to planning and realization of travel, its analysis (e.g. travel diary). Technology design contains mainly elements bound up with data analysis and integration.

In the opinion of the Author, three of these four areas are strictly related to IT development, namely service, technology and finance design, but of course, the most important for IT are those related to technology. However, most of service design and finance design elements is connected to data sharing, analysis or integration, so it is obvious that they should also be made by software developers.

Table 4. Functionalities and elements of MaaS IT solutions (with division into four areas according to Bouwmann et al. [2]

Area	Element/functionality
Service design	Journey searching (fastest, cleanest, cheapest)
	Trip planning
	Trip advising
	Trip comparison
	Traffic analysis
	Price analysis
	Journey booking, integrated booking
	Activating tickets/trips
	Checking trip history
	Customer service (24/7 service)
	Application and web solutions
	Detection of passive deviations (e.g. Weather) and active (e.g. Driving too slowly)
	Navigation system
	Online information about delays
	Feedback messages system
	Integrating other city mobility services
	Travel diary and its analysis
	Integration with planned meetings and mobility assistance
	Intermodal routing analysis, inter-solution routing analysis
Technology design	Integration of real-time data including open data (e.g. Timetables), social media data, sensor data and crowd data (e.g. User device data)
	Data safety
	RFID
	Real-time service
	Compatibility with iOS, Android and other operating systems
	Big data analysis
	Trip forecasts system
	Fleet management options
	Integration with Decision Support Systems
	Cohort analysis and forecasting
	Layout personalization posiibilities
	Real-time connectivity between vehicles (so-called V2V) and between vehicles and infrastructure (v2i)
	Integration with calendars (MS Outlook, Google Scholar)

Table 4. (cont.)

Area	Element/functionality
Organization design	Integration of service providers (including emobility providers and public transportation)
	Organizing partnership model with other providers
	Project management issues
	Product lifecycle management
	Integration with partners
	Defining data sharing policy
	Revenue and cost sharing agreement
	Defining geographical scope (regional, regional and urban, only urban)
	Defining number of modes
Finance design	Payment
	Price models
	Checking balance
	Currency rates integration
	Charging
	Calculating fixed costs
	Payment possibilities
	Common payment tools and clearing procedure

Source: own elaboration based on [1, 7, 8, 11, 12, 14-17, 26, 27, 29-31]

Organization design is coupled with management issues more than IT ones, but of course results of tasks in this group have to be translated into some functionalities of developed MaaS software. In Table 4 are presented only elements identified in analyzed literature sources, it is possible that there are some other functionalities of the described group of IT solution, that should be mentioned when talking about MaaS solutions. The Author believes that elements and tasks mentioned in Table 4 are the most important ones, which should be done within MaaS software development projects.

5. Conclusions, research limitations, future research directions and plans

The article showed that MaaS group can be an answer for emerging economic megatrends, among others with these related to generational change and its derivatices: new mobility patterns, behaviors and growing importance of the sharing economy idea in a life of urban and rural residents. MaaS solutions are attractive for users who cannot afford or do not want to buy assets but want to use them on-demand. Then they do not have to give up travel comfort and can use the new-

est models of assets. Therefore, the answer to the first research question is made. What is more, MaaS solutions are provided in the virtual space (web portals and/or mobile applications), so obviously they are related to IT development. Their growing importance for residential mobility, especially in urban areas determine the need for developing new IT solutions. Additionally, they have to contain many different functionalities making them attractive to users, and some level (the best is advanced one) of the ticket, payment, mobility packages and ICT integration, what is crucial for their market success. Therefore, there are many challenges for IT providers to meet the needs not only of final customers, but also traditional mobility service providers, public transport services providers and others.

In the light of all content of this paper, MaaS should be considered as a future potential direction of development of IT services. This article extends current literature by summarizing available research results from different research methods, research procedures, research samples and geographical areas. However, despite analyzed research papers about MaaS services or these about intermodal transportation, mostly in urban areas, there is still a research gap in this research area, which needs to be filled. There are still too few research results about MaaS development, especially in IT area.

The material collected in the article is the starting point for empirical research on the development of new patterns of urban mobility, new business models, as well as the development of methods and tools used in urban public transport. It is also a basis for research about MaaS solutions – their architecture, functionalities, examples (e.g. comparative analysis).

There are few limitations of this article. Research methodology concerns only papers with particular search criteria, but there are probably also other works dealing with MaaS in the context of sharing economy development. What is more, there is a risk that the Author did not include all possible MaaS elements or functionalities, but only these identified within literature analysis research procedure. Research results should be discussed by other researchers undertaking their research in the area of sharing economy, mobility, mobile application and web portals development.

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