The Business Ecosystem of Mobility-as-a-Service

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Abstract

Mobility as a Service (MaaS) is a new mobility model that aims to bridge the gap between public and private transport operators on a city, intercity and national level, and envisages the integration of the currently fragmented tools and services a traveller needs to conduct a trip (planning, booking, access to real time information, payment and ticketing). As MaaS gains wider acceptance, there are several misperceptions about what this model is. Thus, the purpose of this paper is to provide a preliminary definition for the MaaS concept, and propose the MaaS ecosystem where the role of each actor is described in details. The MaaS ecosystem is designed after personal interviews and focus groups with the involved actors. This holistic approach sets the ground for the MaaS concept and highlights the areas where research is needed in order to contribute to the materialisation of the concept.

Keywords: Mobility as a Service, Business Ecosystem, Service design, New mobility services

1. Introduction

Hyper urbanization, climate change, and demographic and societal changes are some of the megatrends that have imposed pressure on the transport networks and set obstacles for door-to-door mobility. For most of its history, the transport sector has remained largely unchanged, characterised by slow incremental innovations due to the costly infrastructure. The new information and communication technologies (ICT) increasingly foster the development of business concepts for more efficient use of vehicles, optimisation of the transport network, better infrastructure utilisation, and seamless trips.

Taking advantage of these technological breakthroughs, several new business models have emerged recently. One of these is the Mobility as a Service (MaaS) model. MaaS aims to bridge the gap between public and private transport operators on a city, intercity and national level, and envisages the integration of the currently fragmented tools and services a traveller needs to conduct a trip (planning, booking, access to real time information, payment and ticketing). It has the potential to eradicate dependence on private vehicles and deliver seamless mobility as it allows the integration and cooperation across transport operators, the bundling of transport services and their provision to travellers as one product via a single interface. Through MaaS, travellers could have access to easy, flexible, reliable, price-worthy and seamless transit from A to B whether it is urban or intercity trips.

The MaaS model is expected to be a paradigm shift in the way mobility services are distributed. However, many practitioners point out that it is rather easy to come up with new ideas, but the real challenge is putting them into practice. Designing a business model and institutionalizing it is especially demanding when innovations occur outside the exclusive control of traditional firm boundaries (*1*, *2*). Research shows that diffusion of innovations in transport is particularly slow and requires a credible evidence base (*3*), observability, strong leadership and trust (*16*), as well as strong social interactions between professional groups and suitable organizational contexts (*3*, *4*). The necessary changes for MaaS and most of the new mobility services are of a systemic nature (*5*) and require a business ecosystem (*6*) where multiple organizations act in collaboration (*7*), mixing the traditional boundaries of business sectors and companies, and involving users in the co-creation (*8*, *9*, *10*).

Against this background, there is an imperative need to design the MaaS ecosystem and identify the actors involved and their roles. As MaaS gains wider acceptance, there are several misperceptions about what this model is. Thus, the purpose of this paper is to clear up the confusion and define what is meant by MaaS. More specifically, this work aims to: 1. provide a preliminary definition for the MaaS concept, and 2. propose the MaaS ecosystem where the role of each actor is described in details. The MaaS ecosystem is designed after personal interviews and focus groups with all the involved players (users, transport authorities, MaaS providers, technology companies and policy makers – data have been collected from stakeholders in the UK, Finland, Sweden, Luxembourg, Germany and Hungary). The theories of business ecosystems (*6*) and disruptive innovations adoption (*10*) are used as basis to design the MaaS ecosystem. This study also follows a design science approach, which has its roots in the pragmatist research philosophy (*11*, *12*). This approach is mainly used by information systems researchers studying creation, transfer, and penetration of innovations (*13*, *14*, *15*). Although these approaches are widely used in other sectors (such as telecommunications, healthcare etc.) to explore ecosystems and the transformation that is needed to absorb innovation, to our knowledge, they have not been utilized yet in the transport sector. Our holistic approach also offers the ground for the multi-disciplinary research that is needed in order to contribute to the materialisation of the concept.

The following section provides the definition of the MaaS concept. Section 3 presents and discusses the MaaS ecosystem. Section 4 concludes the paper.

2. The Mobility as a Service Concept

The MaaS model covers several concepts that have been extensively discussed in the transportation sector during last decades. These are the integration, interconnectivity and optimization of the transport services, smart and seamless mobility, and sustainability (*17*). The model also includes concepts that have recently emerged via the Internet of Things and the sharing economy, such as the term "as a service" and personalisation. Although there are already mobility services that cover these terms (i.e. car-sharing, on-demand transport), they usually operate in silo and are not integrated with other modes - especially with public transport. MaaS envisages enabling a co-operative and interconnected single transport market and providing users with hassle free mobility. In order for this to be achieved a new player has to enter the transport market, namely the MaaS provider. The MaaS provider should be able to remove many of the pain points that are related to travelling and offer users an advanced travel experience. Building on these, MaaS is defined as follows:

Mobility as a Service is a user-centric, intelligent mobility distribution model in which all mobility service providers' offerings are aggregated by a sole mobility provider, the MaaS provider, and supplied to users through a single digital platform.

Currently, the user has to use numerous tools in order to find information and purchase and access different transport modes. Travellers usually use different journey planning tools to plan their trips. However, most of the existing journey planners do not offer information for intermodal trips (that is, do not combine more than one transport mode – with the exception of walking that is usually the access and egress mode), and only include some of the available transport modes in an area. Furthermore, the user has to use different payment methods for each transport mode; for example some transport operators only accept cash, other accept cards, smartphone payment or PayPal. Once again, the user mainly needs different tickets/ways to access each mode (recently in many cities around the world, public transport modes are accessed using the same ticket/smartcard, but there is no ticket integration with other transport modes). These are only some of the pain points that deteriorate our mobility and hinder intermodality (refers to the use of two or more transport modes in a trip; *18*) or multimodality (refers to the use of different modes for different trips; *18*) and the choice of sustainable travel behaviors.

The MaaS concept removes many of these user-related pain points. The MaaS provider is an intermediate between transport operators and users. The MaaS provider uses the data that each transport operator offers (via secure APIs - details regarding how this works are given below), buys capacity from the transport operators and resells it to users. The users only use one interface to find information and choose the preferred transport mode for their trips. The MaaS operator can propose the ideal combination of transport modes to them for each trip by knowing the network conditions in real time (supply side) and the preferences of users (demand side). In other words, the MaaS provider can optimize the supply and the demand. To explain through a comparison, the MaaS provider could act as Expedia does in the tourism sector or as Amazon in the retail sector; instead of visiting and searching the websites of each hotel, airline or car rental company, customers can find all the information they need on one website, and they can purchase one service or combinations of services in a one-stop-shop manner.

MaaS envisages not only bridging the gap across transport operators in the same city, but also across different cities and initiates the idea of roaming in the transport sector. Nowadays, it is common for someone to live in one city (usually due to better quality of life or properties prices) and commute to another. At the same time long-distance business trips have been increased. The MaaS providers could cover the travel needs of their customers not only in their home-city, but anywhere around the world where they operate. This is already a feature that some of the on-demand and car-sharing services offer. For example, you can use/access Uber in all the cities where the company operates by using the same app and by having exactly the same user account and payment details. Figure 1 depicts the current situation for urban and intercity trips from a user's point of view and the way transport services could be accessed when a MaaS service is available.

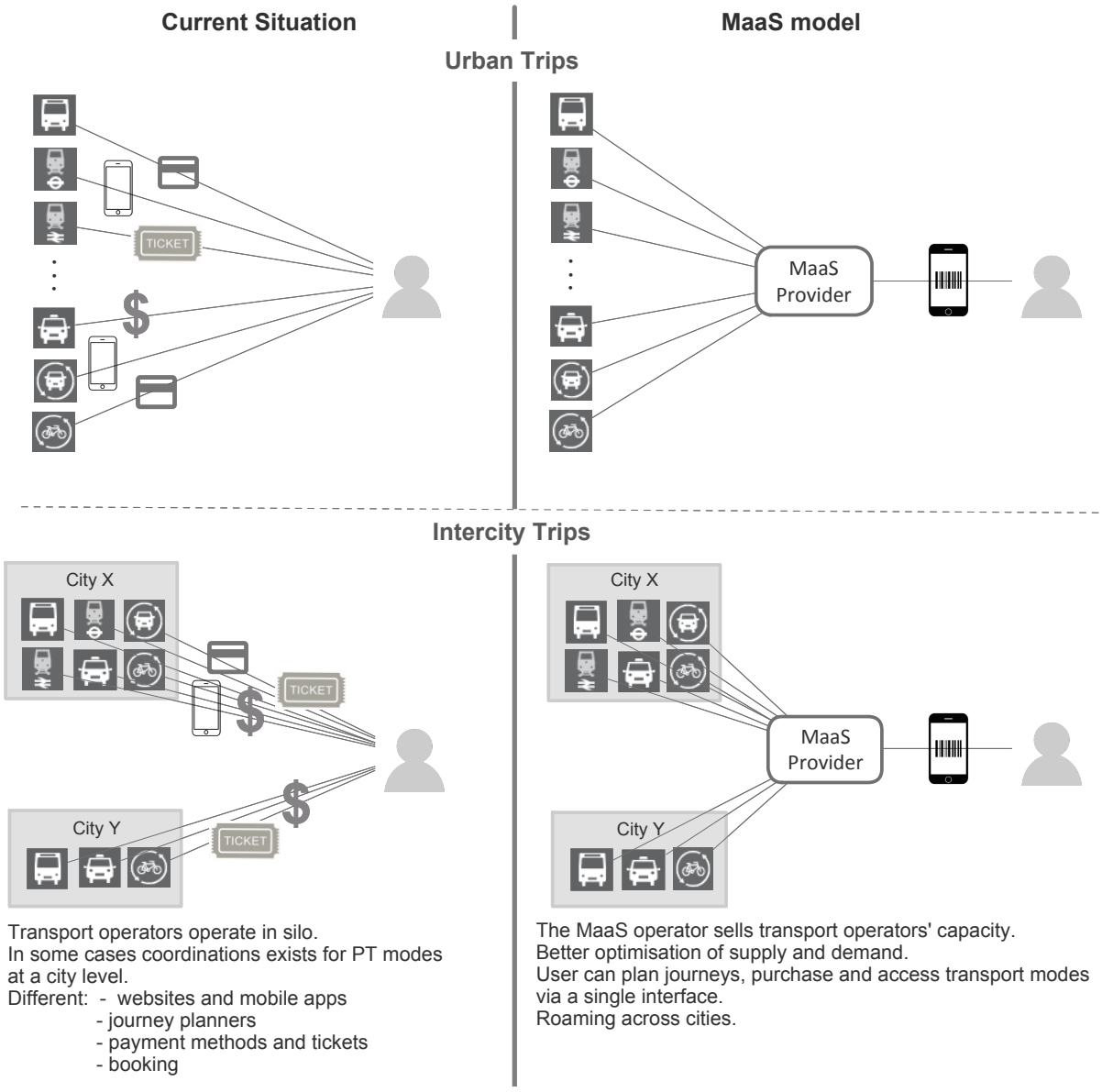

Figure 1: With and without MaaS from user's perspective

The way and the variety of services that MaaS providers could offer depends on the supply side and the intelligence of each operator. MaaS is a subscription service that could provide either pay-as-you go options or subscription packages that include various combinations and amounts of transport modes (similar to the telecommunications and broadband sectors; for more details see *18*). The MaaS providers could offer business-to-customers (B2C), business-to-business (B2B)

services or both. For example, MaaS operators could offer services to individuals, but also corporate services to companies for the business trips of their employees.

While currently only the transport operators are considered in the supply side, other companies could also enter the MaaS arena. For example, the subscription packages could also include free Wi-Fi access while travelling, free access to newspapers and magazines, movies, music and gaming services, and even discounts to coffeehouses and restaurants to buy food for the trip. Once the MaaS providers start offering their services, more and more ideas will surface to improve user experience. In addition, all these bundled services will make even more sense in the autonomous vehicle era, as it is expected that travellers would have the opportunity to do plenty of other activities instead of driving.

3. The Mobility as a Service Ecosystem

This section presents the Mobility as a Service business ecosystem. A business "ecosystem" is the wider network of firms that influences how a focal firm, in our case the MaaS provider, creates and captures value (*6*). Firms designing a business model with a perspective on the developing ecosystem of companies around them have to make a conscious decision regarding their position in the value chain. The "function" in the ecosystem that they want to serve in the delivery of MaaS services has to be determined. While this concept of strategic "positioning" is not new in business model theory (*19*), the MaaS model as a complex value proposition presents new specific challenges in restructuring the value network. The elaboration on the ecosystem is based on data collected from focus groups and interviews with senior managers, company founders and CEOs, users and policy makers in the UK, Finland, Sweden, Luxembourg, Germany and Hungary. The elaboration apart from value creation and proposition, also highlights areas where research and further innovation is needed.

The ecosystem of the MaaS provider consists of several actors, including: 1. transport operators (this term also includes mobility service providers, i.e. parking space providers), 2. data providers, 3. technology and platform providers (technical back-end providers), 4. ICT infrastructure, 5. insurance companies, 6. regulatory organisations, 7. universities and research institutions. As the MaaS ecosystem evolves other actors could also be added, such as media, marketing and advertising firms, unions and other stardisation bodies. But for the purposes of this paper we will focus only on the actors that could enable (or disable) the concept at its first steps. The MaaS ecosystem is presented in Figure 2.

A business ecosystem is composed of several layers, which correspond to differing levels of commitment to the MaaS provider (*6*). The ecosystem's *core business* layer consists of the MaaS provider (the focal firm) and the parties forming the heart of the business: the business network actors such as suppliers and customers. In the case of the MaaS provider, the core business parties are the transport operators, the data providers and the customers. The next layer, the *extended enterprise*, widens the view of the business supply chain to include the complementors and second-layer suppliers. In the MaaS ecosystem these are the technical back-end providers (IT infrastructure providers), firms offering ticketing and payment solutions, ICT infrastructure, and insurance companies. The outermost layer, the *business ecosystem*, adds regulators, unions, universities and other research bodies, investors, and stakeholders to the business ecosystem. Even though they are perhaps not directly involved in the business operations, these parties may have a significant effects on the success of the MaaS model. Below the role of each actor is described in details.

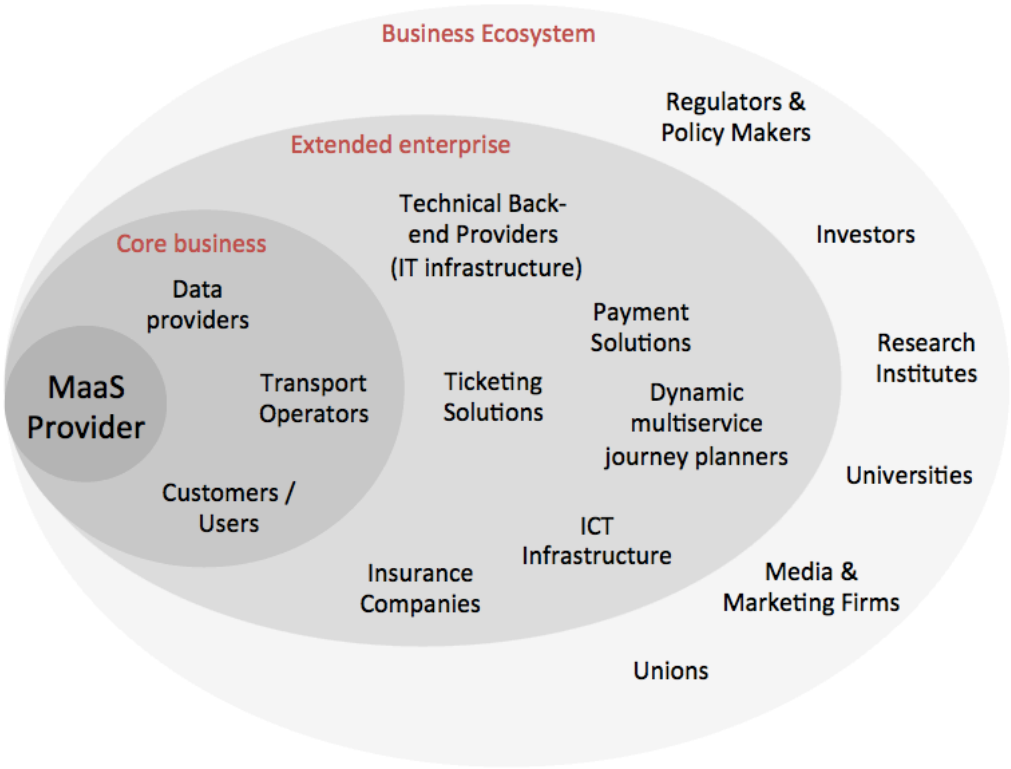

Figure 2: The Mobility-as-a-Service Ecosystem

The MaaS Provider

First of all, it is of crucial importance to define who could be the MaaS provider. Via our interviews we concluded that there are two prevalent options. The MaaS operator could either be a public transport authority or a private firm. Both options have advantages and disadvantages.

In the case where the transport authority is the MaaS provider, it is easier to secure that all the public transport modes of the city will be offered via such a service. In addition, due to the fact that in most cities the public transport authority is the one responsible for authorising (or procuring) all the other transport operators (i.e. taxi, car-sharing etc.), it would be easier to secure their participation in the MaaS service. Furthermore, the public transport authorities are frequently also the transport regulators and as such it may take less time to regulate to enable the MaaS concept. However, public transport authorities may find it too difficult to diversify or extend their role and this transformation could take years. Similar to many other public authorities, transport authorities' bureaucracy may slow down the innovation penetration. In addition, the public transport authorities are not-for-profit organisations and probably do not have the incentives or they are constrained by law to develop MaaS services that could really advance the travel experience. Concepts such as those that were discussed in the section above (i.e. offering discounts at coffeehouses, or free movies downloads etc.) are probably too difficult to be included in the MaaS service design due to fair competition standards. Another disadvantage of the public authority acting as a MaaS provider is the fact that the concept of roaming (connectivity with other cities) is challenging to achieve; it is out of their scope to develop services that could be used to other cities as well.

In the second case, the MaaS provider is a private firm. It could be a firm that is established with the sole purpose of offering MaaS services or an existing firm that will either diversify or extend its current services. Under this option, it is expected that the MaaS market would be developed faster. Private firms are driven by profit maximisation and they put a lot of effort on developing

unique intelligence and know-how and on designing services that offer advanced and personalised experiences. Another finding from our interviews with transport operators is that private transport operators such as car-sharing companies and on-demand modes would prefer to provide their services via a privately owned MaaS provider as they believe that it has more incentives to promote their services. In addition, it is easier for a private firm to offer roaming services as scaling-up is one of the most companies' goals. However, it is expected that it will take a lot of time for public transport services to join the MaaS schemes. One additional possibility is that the public transport authorities would be afraid of losing their reputation as the transport integrator and provider of the city

Other MaaS business models were also identified, such as a private MaaS provider to offer franchise to local companies in each city, or the public transport authority to procure for a private MaaS provider (public private partnerships). But these are specific business models that will emerge once the MaaS market is enabled. However, they include the two main options that were discussed above.

The MaaS concept opens a new global market that is claimed to be a multi-trillion dollar one (*21*). New business models should be developed in order to further investigate the exact relationships that the MaaS operator will have with the suppliers, the legal agreements, the organisational structures, the service design, the revenue allocation models and the specific value proposition.

Transport Operators

Transport operators are one of the main suppliers to the MaaS provider and are positioned in the core business ecosystem. Transport operators sell their capacity to MaaS operators and provide access to their data via secure APIs (Application Programming Interfaces). To fully enable the MaaS concept by offering the required data, transport operators should ideally have sensors on their fleet, and ticketing systems that accept smartphone reading. Other mobility related services, such as parking and toll operators or EV charging infrastructure operators could also be included in the concept and in the MaaS service design.

The MaaS provider creates value for the transport operators in several ways. First of all, transport operators via the MaaS provider have the opportunity to access a wider market and increase their market share. In addition, the MaaS operator could optimize demand and supply by knowing in real time the demand and the capacity of transport operators. This would be especially valuable in peak hours when some of the transport operators run on full capacity and the MaaS provider could redirect their demand to other transport operators and avoid passenger dissatisfaction. As such, transport operators have the opportunity to grow their revenue from previously 'unreachable' customer markets (21) and increase the level of satisfaction of their customers. The MaaS provider also creates potential for competition between engaged transport operators leading to improved levels of mobility services.

Data Providers

The data provider(s) is the other key supplier to the MaaS provider. As the MaaS concept relies heavily on interoperable data availability, the role of the data provider is of critical importance. The data providers offer data and analytics capabilities to MaaS providers. They process the data of the transport operators and collect data from a range of other sources (i.e. customers' mobile phones, social media etc.). The multi-dimensional, ubiquitous data capture, with mobile devices and sensors about services, infrastructure and users that a MaaS provider needs, should be stored and retrieved in a fast, reliable and secure manner. The traditional technology architecture will not be able to accommodate such unprecedented levels of scale, speed and data variability. As such, advances in big data need to be exploited in order to provide the technological foundation for large scale data collection, storage and analysis. Concepts that employ cloud computing, such as the

NoSQL database technology will need to be explored to facilitate the agile and real time data management requirements. Scalable data warehouses and large distributed file systems must be regulated by strict security and data policy requirements to ensure the latest encryptions tools and protocols are applied and followed.

The data providers process, repackage and make the data available in interoperable formats (by interoperability, we mean the ability of all devices, systems and infrastructure within a single MaaS scheme, as well as among the whole global MaaS ecosystem, to communicate information by being able to read, understand and translate each other's data). Data interoperability is of strategic importance to the MaaS model. In order to achieve interoperability, regional as well as national and international data standards and protocols need to be proposed on a central policy level and adopted by the transport operators. Another aspect to consider here, is the fact that the MaaS model could be fully enabled by data being openly available. This can be expedited by creating policies and standards that support secure open data and sources.

The data that each MaaS provider will require depends on its service design. The essence of the necessary data and an overview of these can be seen in Figure 3.

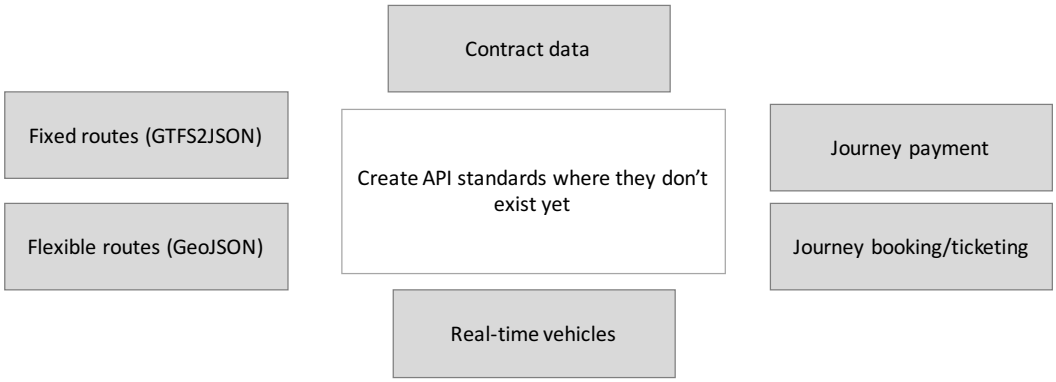

Figure 3: Minimum data requirements for enabling the MaaS concept (Source: http://www.slideshare.net/pippuri)

Most of the currently available transport operators' APIs only provide capabilities for planning and are widely used by the numerous journey planners available at the disposal of today's travellers. In the MaaS model, however, besides APIs for planning, real time vehicle and route information as well as booking and ticketing information is required. The incoming API information needs to go through an API gateway, where the traffic is filtered according to access control and safety while the metrics are captured and logged. The traffic is then redirected and routed to the appropriate area of the MaaS and data providers' back-end systems. Open and interoperable APIs for data provision and access as well as sensor data from services and the infrastructure are all essential.

The MaaS concept gives access to new markets for data brokerage services creating opportunities for additional revenues and market growth.

Technology

Technology-specific actors offer technological solutions and support to the MaaS provider in order to develop its own intelligence and platform. The architecture of each MaaS providers' platform will probably vary based on its business model. That's why it is out of the scope of this paper to go into details of how the MaaS providers' platform architecture could be (an example of a MaaS provider's platform architecture could be find at: http://www.maas-api.org; this is the MaaS.Global's open API for its platform). However, there are certain elements that a MaaS provider's platform will need to host and these are the dynamic multiservice journey, and the ticketing and payment solutions. As the objective of the MaaS provider is to provide advanced

services to customers, it is probably out of its scope to develop technologies from scratch that are already well established and widely used.

Dynamic Multiservice Journey Planner Providers
There are numerous available journey planners in the market as well as open platforms for journey planning (i.e. OpenTripPlanner). The MaaS provider has the option host an already available journey planner on its platform. However, the some of the currently available journey planners offer multimodal journey planning capabilities but barely any intermodal. In addition, they usually only include part of the available transport modes in an area focusing mainly on public transport modes (bus and underground), private vehicles, cycling and walking. Real-time information has started becoming a popular feature of the latest journey planners (wherever the appropriate data is available).

To enable the provision of advanced MaaS services, journey planners should develop new capabilities and especially intermodal planning capabilities that include all the available transport modes in an area (of course, this depends on the data that each transport operator provides as discussed above). In addition, journey planners should become dynamic; meaning to have the ability to adjust to a variety of anomalies (i.e. network disruptions, high capacity etc.) of the transport network and evaluate the most cost effective ways to get from A to B given the conditions on the network and the capacity of transport operators in real time.

The nature of the services that a MaaS operator envisages providing motivates journey planning firms and research communities to develop further innovation. The MaaS provider could add additional value to these firms by feeding them with data regarding users' location and demand.

Ticketing and payment solutions providers: The technologies that are currently available regarding payment are quite advanced offering opportunities for payment with credit cards, smartphones and linking PayPal accounts. The MaaS provider could co-operate with firms that offer such capabilities so that the customers are able to pay for their MaaS purchases. Similarly, many technologies are available for ticketing with the most advanced one being digital wallets (smartphone wallets). Due to the fact that MaaS services are offered via smartphones, the ideal ticketing solution is these smartphone wallets. However, the technology a MaaS provider will choose depends heavily on the transport operators ticketing technologies. An ideal solution should be found so that the customer is able to access as many transport modes as possible with one ticket. Combinations of ticketing technologies could be another solution, but in this case the customer has to deal with holding more than one ticket. This would not be ideal as the core idea behind MaaS is to offer a simplified journey experience to users.
The MaaS provider generates extra revenues for both ticketing and payment solutions firms.

Technical backend providers and IT infrastructure: The MaaS model is enabled by technological breakthroughs such as big data availability and cloud computing. As such, it is of vital importance for a MaaS provider to co-operate with a reliable backend provider. Nowadays there are several on-demand cloud computing services that can respond to the needs of a MaaS provider. The MaaS model generates extra revenue to these providers.

ICT infrastructure: Internet connectivity is also critical to any MaaS provider. MaaS customers should be able to access the service via the MaaS mobile application or the website in real-time in order to request a transport mode for their journey. Furthermore, the MaaS operator should be able to transfer customers' requests and the data in real time. As such, high speed internet (3G and 4G) and widespread geographical internet coverage is a key enabler to the MaaS model. The MaaS model could further increase the revenue of the ICT companies.
Insurance companies

The MaaS model unravels new business opportunities for insurance companies providing them the option to expand their portfolio and increase their revenue. Traditionally, insurance companies' portfolios mainly focused on private motorised vehicles and their passengers' insurance, while in recent years they have been expanding in air-passengers' insurance and compensations (air-passenger protection rights). In the MaaS market, there are several questions that insurance companies and legal offices will be called upon to provide solutions for. For example, what will happen in cases where the MaaS provider proposes a transport mode to a customer and the transport mode is unable to respond to the request in a given time window. The customer could claim passenger rights and request compensation. But the question is who is going to pay for this; the MaaS provider that proposed the mode or the transport operator that was not able to respond? Many similar questions will arise once the MaaS providers will start operating. This is a field that the research community could head to.

Investors

As mentioned above, preliminary estimations indicate that MaaS is a trillion dollar market providing an opportunity to investors to exploit. The MaaS market could attract not only private investors, but also public funds. For example, public authorities support concessionary travel schemes, while subsidize public transport operators, especially bus operators. Part of these funds could be redirected to MaaS providers as it is assumed that they could better match supply and demand saving as such public money and reducing bureaucracy. Another option is the crowdfunding. However, these options need further investigation on how could efficiently be applied.

Regulators and Policy Makers

Although, regulators and policy makers are positioned in the outer layer of the MaaS ecosystem, they are the key actors that could enable the MaaS market. Since this concept includes open data and open APIs, they are those that can provide and regulate for open standards and interoperable data formats. They could also provide policy frameworks and recommendations for the sustainable development of the market, fair competition, financing, passenger rights, privacy and security, service quality standards, social inclusion, and safety. The ideal is the policy framework to be proposed by the government on a national level in order to avoid different open standards across different regions that will hinder interoperability. Moreover, as one of the goals of MaaS providers is to scale-up in several countries, the open data standards could be proposed by an international organisation (for example, the MaaS.Alliance is an NGO that has been established to promote this idea and enable the MaaS market). The regulators could spark the fire by providing these standards and then let the market grow. It is assumed that the development of the MaaS market would be similar to the telecommunication market (i.e. global standards for GSM networks – global roaming).

The MaaS model creates value to the society and to authorities. It provides opportunities for more efficient use of transport management tools and resources/data to meet the needs of citizens. It could also contribute to a more effective redistribution of the government's mobility subsidies. MaaS providers (in case of private firms) will pay taxes generating income for the governments. Finally, the vision of the MaaS concept is to reduce car ownership while providing equally convenient but sustainable transport options. In doing so, this model contributes to sustainable development.

Unions / Lobby Groups

Unions usually slow the innovation penetration and could also slow the development of the MaaS market. A recent example is the one of Uber and the taxi unions; a private firm entered the on-demand transport market disrupting the business-as-usual model. This has resulted into legal fights, while in some cities Uber is not allowed to operate anymore. In order to avoid similar

situations in the future, the authorities could develop checklists with the minimum standards a MaaS provider could have in order to operate in an area (licensing MaaS providers).

Universities and Research Institutes
Since MaaS is a new concept, research is needed in several sectors of the ecosystem as described above. Research could provide quantified evidence regarding all the aspects of this concept allowing the regulators to develop the appropriate enabling frameworks. Research could contribute to the technological innovation that is required to enable the MaaS idea. It could also assist with the development of the business models, the financing structures, the insurance schemes and the revenue allocation models. At this early stage, research is an important enabler of the concept.

Customers
MaaS is by definition a user-centric model. MaaS providers are established having as a vision to add value to customers and the society as a whole. Customers belong to the core business of the MaaS provider and are key players to the ecosystem. Based on the business model of the MaaS provider (B2C, B2B, B2C&B2B) the customers could be individuals, companies or both. Another concept is that the MaaS providers could offer services not only to passengers, but also to freight sector. Further definitions are needed regarding who could be the customers of the MaaS providers. For the purposes of this paper, we consider passengers as the customers.

The MaaS model adds value to the customers by offering them hassle-free, price-worthy and personalised mobility. The demand for MaaS, the service design, the willingness to pay for using MaaS services and the impact that MaaS could have on travel patterns are topics that research is needed in order to motivate regulators to speed up establishing the standards. However, customers is the only actor that research has started conducting about. For example, Kamargianni et al. (*18*) proposed a framework to personalise MaaS services and mobility packages; Giesecke et al. (*20*) proposed a conceptual framework for increasing the acceptance of MaaS from a user perspective; Sochor et al. (*22*) explored MaaS users experience and attitudes and perceptions about the service using data from the first MaaS pilot worldwide.

4. CONCLUSIONS

Mobility as a Service is a newly emerging phenomenon in transportation that has been receiving increased attention in the past year. This study aimed at providing a definition for the MaaS concept while exploring a holistic approach to design the MaaS ecosystem. Circling back to the definition that was carefully constructed in section 2, we can now see why all the elements included are crucial:

- It is *user-centric* because creating seamless door-to-door intermodal and multimodal journeys for customers is the main purpose of MaaS;
- It is a *mobility distribution model distribution model in which all transport operators' offerings are aggregated by a sole MaaS Provider*, which emphasises the fact that MaaS is not solely an integrated mobility service but rather a complete restructuring of mobility supply – with the MaaS Operator at the core;
- It is *intelligent* and *supplied to users through a single digital platform*, stressing the importance of ICT and IT infrastructure in the functioning of MaaS systems.

Several actors are involved in the MaaS ecosystem; namely: 1. transport operators, 2. data providers, 3. technical backend and IT providers, 4. ICT infrastructure, 5. insurance companies, 6. regulatory organisations, 7. universities and research institutions, and 8. Customers. The actors have been categorized based on the relationship they have with the MaaS provider. However, as

the MaaS ecosystem evolves other actors could also be added. Although regulators and research institutions are positioned in the third layer of the MaaS ecosystem, their role at this early stage is of vital importance; researchers could provide quantified evidence regarding how this model could work and what impact will have providing as such rigorous arguments to regulators to enable the market.

Even though this examination only grazes the surface of the intricate MaaS ecosystem, it is the first work, to our knowledge, that approached the MaaS concept from a holistic point of view and can be used by researchers and decision makers as a foundation for future MaaS research and development.

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