A Holistic Overview of the Mobility-as-a-Service Ecosystem

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Abstract: Integrating mobility services to provide better intermodal user experience has been an important element of transport policy for quite some time. Springing from this, the Mobility as a Service (MaaS) concept has become the most recent disruptive innovation in the sector. As MaaS research and development are still in their early stages and far from maturity, it is a crucial time to both define the term as well as set up a conceptual framework of what this socio-technical phenomenon actually is. Against this background, the primary objectives of this research are: (1) to give a definition of MaaS that can be used in further research and policy documents; (2) to provide a theoretical framework for the MaaS ecosystem, including elements for consideration from the business, end-user, technology and policy side. These can hopefully be used by researchers and decision makers as a foundation for future MaaS research and development.

Keywords: *Mobility as a Service, MaaS, Integrated Mobility, Ecosystem*

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Introduction

Decreasing dependence on private vehicles has been high on the political agenda in recent years. As such, policy makers have been eagerly implementing various strategies, such as taxes, congestion charging schemes and discounted public transport passes, to push people away from their cars, and pull them towards more sustainable modes. Simultaneously, the needs of travellers have also evolved, and they now demand more flexibility in their mobility options. This not only includes wanting access to every type of transportation mode, but also touches various spatio-temporal aspects with the need for intercity and international door-to-door mobility on the rise. Resulting from these trends, a situation has arisen where a combination of transport modes provides the desired mobility for travellers, while also adhering to policy goals. With the current availability of a vast number of public and shared modes (including public transport, car sharing, bike sharing, traditional-, on demand- and shared- taxi, ride sharing etc.), combining these can provide flexible and private vehicle free options for door-to-door mobility. In the process, the traditional model of service providers working in isolation is slowly being abandoned, allowing for a wave of integrated mobility projects to arise [1]. The Mobility as a Service (MaaS) concept stems from these, but instead of just integrating the modes from the users' perspective, like most of the current projects, it is based on a complete paradigm shift in the way the services are distributed.

Referred to as a disruptive innovation, MaaS has huge potential to provide benefits to every actor in the mobility sector. For users, it can provide easy, reliable, flexible, seamless and price-worthy door-to-door travel that supports all lifestyle requirements. For society as a whole, it can foster social inclusion and promotes socially responsible behaviour. For transport providers, it can support more efficient business models and access to new markets and potential revenue growth. Finally, for governments, the opportunity to address a wide range of policy goals from environmental sustainability, to smart mobility and integration. These benefits can only be truly realised once the concept has been fully examined and tested. As MaaS research and development are still in their early stages and far from maturity, it is a crucial time to both define the term as well as set up a conceptual framework of what this socio-technical phenomenon actually is. Such new and innovative concepts are commonly overused and misclassified, thus it is crucial to distinguish what could fall under the MaaS term.

This paper aims to provide a definition of the MaaS concept, and then take a holistic approach in describing and evaluating the various elements of the MaaS ecosystem. As MaaS gains wider acceptance, one common misperception about the concept is that it is purely another integration model to make it easier for the users to travel with a combination of transport modes. This is true only to the point that the the main aim of MaaS is to make users door-to-door needs conveniently met by intermodal sequences. In addition, this novel mobility distribution model, redefines business models, builds on and promotes technological advancements and creates new opportunities for businesses and research in these respective sectors.

Taking this as a basis, the primary objectives of this paper are: (1) to give a definition of MaaS that can be used in further research and policy documents; (2) to provide a theoretical framework for the MaaS ecosystem, including elements for consideration from the business, end-user, technology and policy side. These can hopefully be used by researchers and decision makers as a foundation for future MaaS development.

The structure of the paper is as follows: Section 2 defines the MaaS concept and sets MaaS in context. Section 3 provides a brief literature review of the current standing of MaaS research. Section 4 outlines the framework of the MaaS ecosystem with the sub-sections detailing each element. Finally, section 6 will draw concluding remarks while pointing in the direction of future research.

1. MaaS Concept

1.1 The Concept

Providing integrated access to multiple modes of transport is not a new concept. Decision makers have been implementing such approaches for many years, building on the abundant evidence that this creates a more seamless intermodal journey experience [2], [3], [4]. Historically, integration has mainly been

among public transport modes however, more recently there has been a wave of projects aiming to solve the disconnect between public and shared modes [1], [5].

These programs have integrated ticketing, payment and information and communication technology (ICT) systems to provide users unified access to the different modes [1]. Such contemporary projects are all based on a user-centric model, where the most important demand-side features are integrated. The Mobility as a Service concept takes these popular digital elements, that is ticketing, payment and ICT integration, and deepens the integration by providing pre-purchasable mobility bundles. But what truly separates MaaS from these projects is the complete modification in the way the supply side is connected and the business models are run. In MaaS, the individual public and private Mobility Service Providers (MSPs) are brought together under the umbrella of the MaaS Operator to abolish any lingering barriers for users. Table 1 provides a simple overview of this idea that MaaS integrates both the supply and the demand side of the concept, which is how it stands out from traditional and contemporary models.

Table 1: Demand and Supply Integration

	Demand Ticket/Payment/ICT	Supply MSP/Business Models
Traditional	Independent	Independent
Contemporary	Integrated	Independent
MaaS	Integrated	Integrated

In many previous attempts to define the concept, the demand side element of the MaaS overshadowed the supply side shifts *(6)*. However, both sides together provide the uniqueness of this idea. Against this background, we define MaaS 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 operator and supplied to users through a single digital platform.

Each element included in the proposed definition plays a very important role in making MaaS an unparalleled idea. In later sections of the paper each item will be addressed and analysed.

1.2 MaaS in Context

Before diving into the ecosystem, it is important to have a look where the MaaS concept stands with regards to maturity compared to other innovations in the sector as well as peoples understanding and perception of the concept. MaaS has all the characteristics of a 'hyped' socio-technical phenomenon [6]. Before this is taken as a negative, it needs to be pointed out all technologies nowadays enter into the so-called 'hype cycle', including some of the most successful products and services that exist. According to this idea, as a new technology or phenomenon is introduced, it goes through a cycle whereby the expectations and visibility of the product/service first increases, peaks, drops and then plateaus [7]. If we place the MaaS concept on such a curve (see Figure 1), and surround it by other transport related technologies/services, we can see that MaaS is still on the 'trigger', that is, on the initial, increasing stage of this curve. It still has a long way to go before the concept becomes mature.

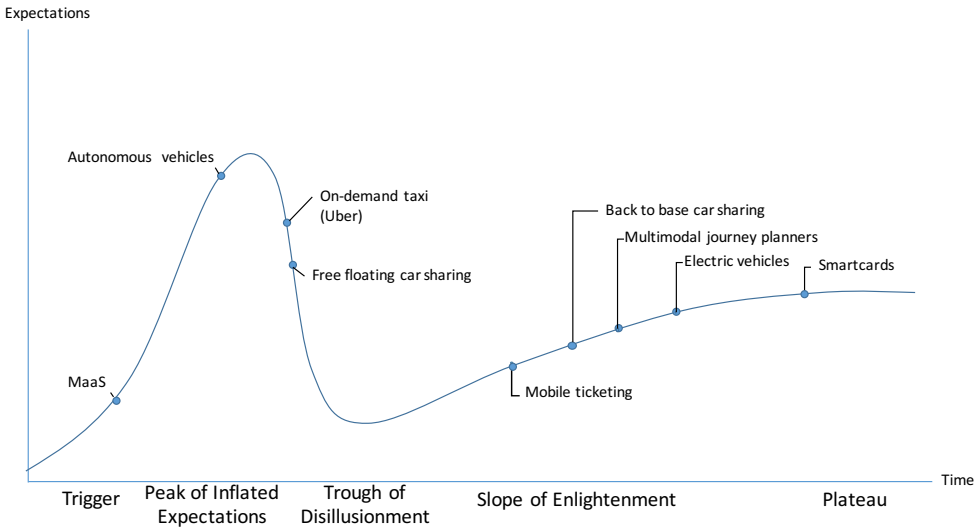

Figure 1: 'Hype curve' for mobility related technologies

The existing MaaS services are all still in their pilot phases (for example Ubigo [8] and MaaS.Global [9] with the Whim app) and there is still much to learn about this innovative and unfamiliar system.

One thing is certain, Mobility as a Service does have the potential to have a significant positive impact on users, the wider society and the mobility sector as a whole. Benefits to users include ease of payment and transactions, which have proved very successful in services such as Uber; real time dynamic information, which builds on the popularity of Google Maps and City Mapper; and enhancing door-to-door journey experience without the user of a private vehicle [10], [11]. Overall, MaaS is necessary but not sufficient for environmental, social and economic sustainability [6]. It can be the facilitator of change, however only if the ecosystem is built in the proper way. Achieving environmental sustainability depends heavily on the type of services included in the concept and the relative promotion of the 'greener' modes. For example, if electric car sharing companies emerge as the norm, this can lead to a much more environmentally sustainable model. Also, the level of openness to behaviour change, such as modal shift, will determine the greenness of the concept. Social sustainability relies on the different policies and regulations that govern the system. The aforementioned social inclusion and inequality concerns need to be a fundamental part of the service for it to be socially sustainable. Finally, economic sustainability is based on the pricing and market structures – whether there is a financing structure that is viable for both businesses and users.

2. Literature

Since research and development of Mobility as a Service schemes are still in initiatory phases, there are only some isolated pieces of literature available at our disposal. Components of these do provide the premise for part of the concepts outlined in this study, thus a short review of them is given to illustrate the state of discourse in the matter.

Since the conception of MaaS in 2014 [12] the understanding and sophistication of studies has significantly advanced. This in no way means they are at maturity – there is still a long way to go before the concept is completely understood. Initial reports placed very strong emphasis on the demand side of the idea [13], [1]. Even now, the most commonly addressed component is the end-user experience and the potential benefits it can have for travellers. For example, the end-user perspective is a core theme in Giesecke et al. [6] who detail how MaaS can increase convenience for passengers and list some possible user acceptance criteria. This is understandable as it is the demand side where many of the easily recognisable benefits can be seen. Besides convenience, such benefits include seamless personalised travel, supporting customers' lifestyle requirements, cost savings [6], [11], [12].

The supply and technological side have started gaining more attention. Callegati et al. for example, focus on describing the functioning of a MaaS enabling tech platform [14]. Two very recent studies need to be highlighted that provide the first attempts at a holistic ecosystem approach for analysing MaaS. Victoria Swedish ICT and the UK-based Transport Systems Catapult [5], [11] have produced subsequent reports about the MaaS ecosystem and reference architecture. Both documents focus on potential MaaS adoption in specific areas: the Nordics and the UK respectively. In the former, even though it can be considered as an 'ecosystem study', much of the report focuses on the organisational perspectives and the role that public transport operator has to play. In the process several important MaaS ecosystem elements are not addressed. The latter creates a MaaS reference architecture, which this current study build onto. The four 'capacity domains' (here referred to pillars) are in line with this paper. Much of the TSC report focuses on the transport policy implications and how these policy guidelines can support the development of MaaS. Interactions between players feature heavily here, which is a definite benefit as the concept relies profoundly on the interplay between actors – this will be further addressed below.

Besides the more theoretical research outlined above, one actual application of the concept, the Ubigo project needs to be noted [15]. This field operation test in Gothenburg, Sweden, public transport, taxi, car sharing, bike sharing and car rental are included in the MaaS offering. Mobility brokers procured services from the providers and offered them to users as one product with the aim of promoting sustainable modes of transport. Operators were motivated to join to expand their customer base and increase their revenue margin (there was only one provider per service type). Overall, there are some very positive steps towards research contributing to better understanding of Mobility as a Service. However, the holistic ecosystem approach is still very new and begs some further analysis. This paper aims at providing a modest addition to this field.

3. Framework for the MaaS Ecosystem

3.1 Overview

The MaaS ecosystem encompasses a wide range of domains including business, technology, end users and policy. We opt for the 'ecosystem' phrasing as the concept is based on an intricate network of interconnected systems, which all interact and cooperate for the functioning of MaaS. The complexity of the MaaS socio-technical phenomenon requires better understanding about how the whole ecosystem could function [6]. It has to be pointed out that this attempt to initiate an exploratory MaaS ecosystem framework will need to be adjusted as the service becomes more mature and the various flows and elements are tested. The presented reference framework was created based on examining online statements, discussions and reports as well as personal discussions with various stakeholders including transport operators, public transport authorities and potential users (the latter in the form of focus groups, but the results of these are out of the scope of this paper) [1], [10].

The MaaS ecosystem framework can be divided into four interlinked pillars, namely the (1) business models, (2) technology (3) end user and (4) policy framework – which are illustrated in Figure 1. These pillars are not independent from each other, their interplay is what makes the MaaS concept unique. The business models include elements of financing, legal and most importantly, organisational structures that bring together all the public and private actors. This pillar also encompasses the next two pillars, as these are governed by decisions made though the business models. The technology domain is dubbed 'technology hub' as it is a centre that connects the front-end and back-end technologies in a unified, standardised manner. The end user is at the heart of the whole concept as creating seamless door to door mobility for customers is the motivation that led to the envisionment of the whole concept. Finally, the policy domain frames the other three, providing the protocols and regulatory foundations that enable successful MaaS schemes to emerge.

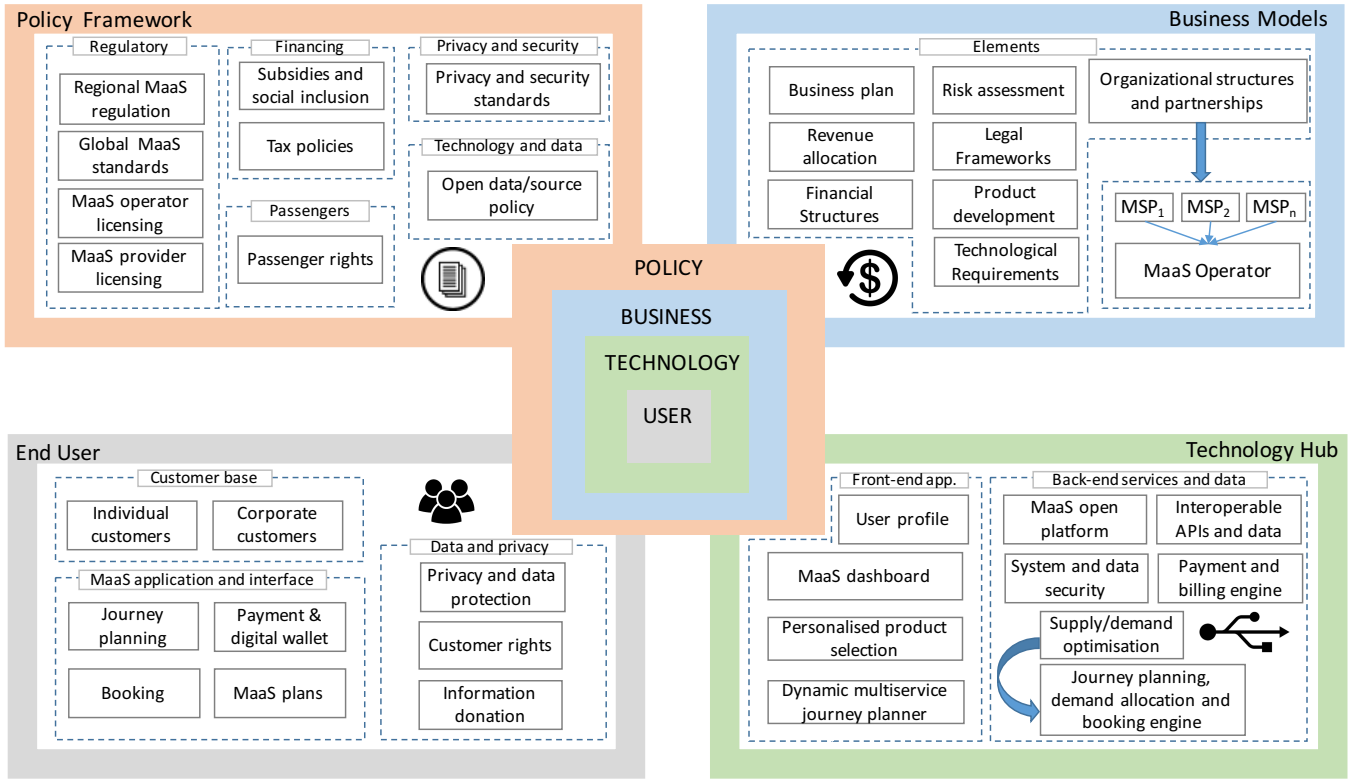

Figure 2: Mobility as a Service ecosystem framework

Before dissecting each element in the framework, the actors and their capacities within the MaaS ecosystem are identified. Stating from the top down, the *political actors* are the first agents to note. Their role is the most passive, as they just pre-specify the regulations and policies to enable the MaaS market, that can not be altered dynamically. In an ideal situation, these actors would be proactive enough to re-evaluate the regulations periodically to adjust to the evolving concept. The second group of actors are the *mobility service providers* (MSPs). These agents provide the actual physical services, but besides that do not interact directly with the users. Instead, they interact with the *MaaS Operator* (MO) who is the new actor compared to traditional transportation service models. The MaaS Operator has been referred to in the literature in various forms such as combined mobility service provider and MaaS provider [5], [11]. Both the MSPs and the MO are very active participants in the MaaS ecosystem and their partnerships significantly affect the success of the whole scheme. The final actors are the *end users.* Customers have a very unique role in the ecosystem as they are both the users of the service as well as providers of information/data at the same time. They, of course, are active participants of the system.

3.2 Business Models

We start our analysis from the business models. The most vital part of the business models pillar is the above-mentioned new player, the MaaS operator, who's role is to integrate supply and offer the mobility services to the users via a single interface as a sole product. The MO's role is key to the ecosystem; it orchestrates of the MSPs while interacting with the end users and providing the technical functioning of the system. As there is no precedent to such an agent, there is no clear archetype of how the MO should come to existence. The emerging structures can be classified according to the ownership arrangements, that is, whether the MO develops as part of a public authority or a private company.

In the case of the former, the transport authority takes over the role of the MaaS operator. Currently, in many cities (e.g. London, Budapest, Athens) the transport authority already acts as the integrator of all public transport modes (bus, metro, light rail, bike sharing etc.) and in some cases allows access via a single smart card [10]. In the MaaS business model, these public authorities could also include the other mobility services (such as car sharing, parking, on-demand modes). In the case of the latter, a public entity is in charge of the MO activities. Here, two options are possible, either an existing MSP can diversify and expand their offerings to include MO functions, or a completely new company can be created with a sole purpose of being the MO. Companies that could diversify could be anything from

small service provider to big multinational companies. With regards to the new company, there is currently only one such enterprise, MaaS Global, who is the first of a kind company created to be a MO.

Out of these potential models, it is not clear which will surpass the others. It is very possible that no one will emerge as the preferred setup; rather each regional MaaS system will select the one that best fits their current level of centralisation, MSP availability and organisation and regional structure. Each structure has their benefits and disadvantages. There are certain key factors that need to be evaluated in each situation in order to determine which structure should be applied. These include existing role and scope of the transport authority, the strength and reach of the potential private companies, the adaptability of the entities, the level of trust in the different potential MOs and whether the proposed MO can remain unbiased. A public sector entity may be favoured in those areas, where the transport authority already has a very strong role. This has the benefit that the authority has the power to influence policy, however it raises some important concerns. The vision of MaaS systems is that a competitive environment is set up, where any mobility service provider (no matter how large or small) can dynamically join the scheme if they satisfy the regulations and standards. With large transport authorities, bureaucracy may slow down the operations significantly, as they are not as adaptable as smaller organisations. To the contrary, private companies can be more adaptable. These entities may however struggle to handle the immense responsibility and strain that comes with being the MO for a whole region and lack authority in influencing policy. In the case of diversified existing private companies, there is also the possibility that the MO functions will take over completely and the rest of the original activities (e.g. service provision) will diminish – making the region loose a supplier. Companies created for the sole purpose of being the MO have one significant advantage over any alternative options in that their whole business model can be set to serve the needs of the MaaS system, instead of having to alter an existing business model that may turn out to be a patchwork setup.

Trust and unbiasedness are very important issues that need to be addressed as they appear in several instances. Since the MO, as the aggregator and integrator, needs to have access to all the providers' APIs and data (discussed further below), the providers need to trust the security of the MOs systems. This may be easier to achieve in the case of a transport authority MO, rather than a private company, especially if the latter is a completely new player. Further, the MO needs to remain neutral and equally promote products from all providers – even if this means services that are potentially competing with the MOs own products (e.g. if the MO is a part of a MSP). Being able to stay impartial is another advantage of a stand-alone MO enterprise as they can promote all services equally without any restrain.

Regardless of how the MO is created, it has a large part to play in the MaaS ecosystem. The MO will be responsible for product development, which will drive the concept forward. The products (for example the mobility plans offered) need to be carefully designed taking into account both the available supply and the end user. Pricing the products will be impacted by the status of the MO, as the public sector can only be non profit and everything needs to be invested back into operations. Private companies are for profit, but as such, will need to pay taxes (this will be further addressed in the policy pillar).

The interactions and partnerships between MSPs and the MO; the end users and the MO and the authorities and the MO all need to be clearly established and the unilateral-bilateral-multilateral formal agreements need to be made. The agreements between the MO and the MSPs are probably the most critical. These will include detailed revenue allocation models, which are critical as the MO is now the body that sells the MSPs' services the users. The most efficient model has yet to be determined, but some of the potential options can be based on the online travel agency industry (e.g. Expedia) such as the merchant model, whereby the MPSs sell services to the MO in bulk at a discounted wholesale price and then the MO sells them on to customers at a markup price; or the agency model, where the MSPs give the MO commissions based on the services bought and the MO does not have to buy anything up front. The optimal revenue allocation model will be influenced by the MO structure as, for example, in the merchant model the MO needs large upfront capital in order to pre-purchase in bulk, which a smaller private company may not have and may also be more risk averse and not want to be end up with potential leftover capacity. Each of these models (and possible alternatives) are an important area of future research.

Finally, for the MaaS ecosystem to be commercially sustainable, there are countless additional elements that need to be further investigated. Some of these include: Financing and the potential adaptation of public-private-people partnerships that could flourish under MaaS; exploring other relationships, such as alliances with payment and security platforms, energy companies, parking management businesses; and

identifying a single consistent unit to allow for interoperable monetisation of all products. The combination of all these cross-company, cross-sector collaborations will build the social and economic infrastructure needed for Mobility as a Service systems.

3.3 Technology Hub

As we dive into the next concentric square of the MaaS ecosystem, we can see that the technology pillar is embedded within the business model pillar, since the technological element is what enables the business models to work. This element provides the whole functioning of the system as it contains all the analytics that are necessary for the ecosystem to operate. It is most definitely the brain of the operations. To provide the services to the users, a single interface needs to be available that combines planning, booking, ticketing and payment functions (front-end). In the back-end, the core is a dynamic multiservice journey planner, which relies on a real time supply and demand optimisation engine. This system is connected with a demand allocation and booking engine, that automates these capacities. The users interact with a MaaS dashboard that includes their user profile and options for them to select personalised products. Finally, the billing and payment engine allows automatic fee settlement.

3.3.1 Back-end analytics

The MaaS platform needs to be able to synchronise data from the different service providers as well as the users in order to perform supply and demand optimisations activities in real time. The MaaS back office will need to have various engines for user analytics and reporting, demand and supply allocation (including journey planning) and user payment and billing. These engines will need to run dynamically in real time and be very stable and secure. Backup systems need to be in place in case of any failures, as if these don't exist and something happens the whole system will crash. As available mobility resources are allocated in real time to fit the dynamic needs of users, a systems breakdown could be catastrophic.

In order for all of these engines to operate, the technology hub depends on fast, reliable and secure data. The essence of the necessary data is provided by the MSPs and an overview of these can be seen in Figure 3.

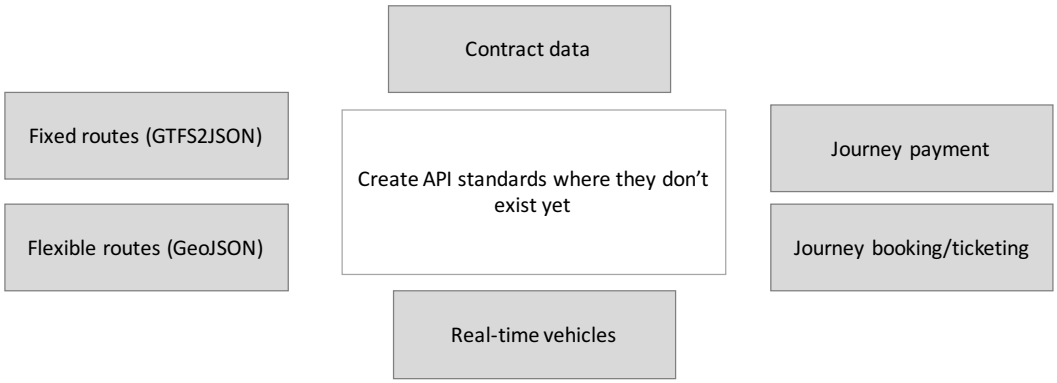

Figure 3. Data sources [15]

Most of the currently available MSP APIs are for planning and are used by the variety of journey planners available at the disposal of today's travellers. In MaaS, 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 platform. Open and interoperable APIs for data provision and access as well as sensor data from services and the infrastructure are all essential. Here, one strategic term needs to be defined: interoperability. 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 providers can play a key role here in making the data interoperable (such as Transport API in the UK). However, once every player adheres data standards and protocols which are adopted on a central policy level, the role of data providers will become redundant. The MaaS platform could be an open platform that all the MSPs have access to and use the open libraries in order to develop their services; or it could be

managed by a third party operator. In the latter case, the MaaS Operator's job is simplified as the platform operation is contracted out, however, the MO becomes bound and reliant on the platform operator.

The back-end also has a critical role in providing the data management infrastructure of the ecosystem. The multi-dimensional, ubiquitous data capture with mobile devices and sensors about services, infrastructure and users needs to 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 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.

3.3.2 Front-End interface and application

The front-end is the program interface that the users interact with directly. In this case it consists of the MaaS smartphone application and the web-based platform that the users see and communicate with. Since the front-end and back-end systems need to be in constant interaction, the front end devices need to be enabled by fast and reliable internet connectivity in the forms of 3G and 4G network coverage as well as onboard and station wi-fi access. The main element of the application is of course the dynamic multiservice journey planner, which is powered by its back-end equivalent. This is where the users plan their journeys, book their vehicles and receive real-time updates about their travel. Further, this is through which users can provide feedback about services immediately when encountering any unusual service conditions. If promoted adequately, this social feedback mechanism can be a vast source of information and a tremendous advantage of MaaS systems. Finally, the application interface needs to have a user profile, where all the personalised elements of the MaaS service can be selected and altered. These include the MaaS digital wallet, which provides the overview of the financial standing of the user; the digital ticket, which the customer uses to access the services; the MaaS plan choosing platform, where they can select the type of monthly plan they want to use and many more.

3.4 End Users

Everything presented in the business models and technology pillars aim at providing the best possible experience for the end users, who are the heart of the ecosystem. The core business model is based around individual customers (B2C) however corporate customers can also be an important addition (B2B). In these latter cases, companies can subscribe to the MaaS platform's corporate mobility schemes and provide their employees and partners with travel allowances. The user needs for both these groups have to be taken into account when designing the service offerings.

We live in an era where user needs are being reshaped and this has to be reflected in the way MaaS products are created and offered. User needs are increasingly heterogeneous and demand mass customisation where products are tailored to their requirements. The sharing economy is becoming much more widely accepted, especially among the younger generations, fostering demand for shift from ownership to usership. The main product MaaS has to offer are mobility packages that serve the multimodal door-to-door needs of travellers. To optimally create these, many individual elements need to be considered on top of the societal changes mentioned above. These, depicted in Figure 4, can be grouped into individual mobility patterns, socioeconomic status and attitudes and perceptions [10].

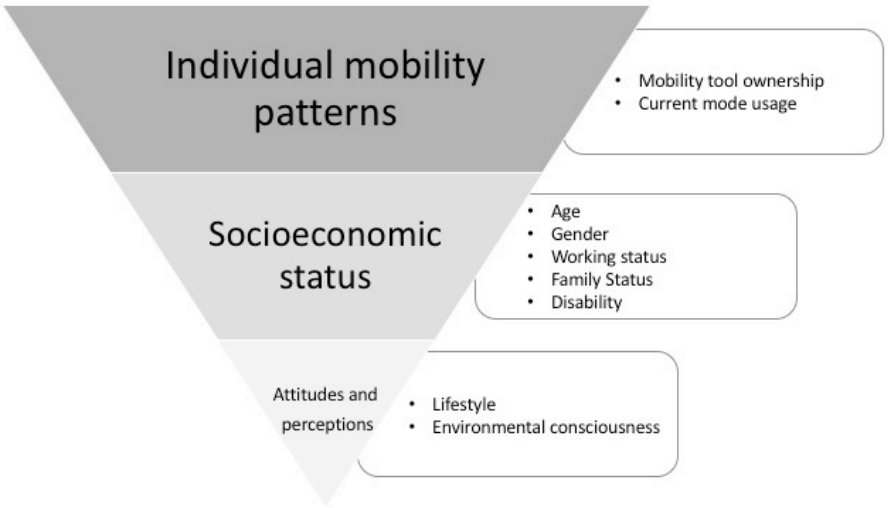

Figure 4: Elements to be considered when creating MaaS plans

Pre-MaaS individual mobility patterns include current mode usage and mobility tool ownership. These provide the basis for any post-MaaS travel behaviour due to status quo bias, commitments, sunk costs and cognitive dissonance. Current behavioural patterns need to be taken as a premise, which will be altered to a greater or lesser extent depending on other characteristics of the individual. These other characteristics include socioeconomic status, such as age, family status and disability as well as attitudes and perceptions towards the environment, health etc. can greatly influence choices and behaviour change. MaaS has the potential to promote more environmentally and economically sustainable modes, which is an objective that also needs to be taken into account when creating the packages [6], [10].

Users play a very unique role within the MaaS ecosystem. They, of course, are mainly the customers of the service. Yet, they also play an important part in shaping the scheme via feedback mechanisms that should be included in the interfaces of the platform. Community feedback can provide real time customer experience responses about elements of the mobility network that may be difficult to collect information about otherwise (comfort). Further, users can be the source of ample amounts of data for analytics, including real time location, service satisfaction and choices just to name a few. One possible concept that can be tested is giving power to the user as to how much of their data they are willing to supply to developers and researchers. Obviously some data is necessary for the system to function, but there is vast and untapped potential in a whole range of other data elements. Instead of systems automatically scraping users' data, through this approach, users would be empowered to decide what should be done to their data. For example, users could be given the option to 'donate' their data to science if they wish. This could be a first-of-its-kind step towards open, automated and consentent transfer of data from users to research scientists.

There are many end user elements that need further investigation and will help shape the design of the products. User responses to the service should be tested in real life experiments and living labs and pilots. These should ideally be conducted in diverse environments, such as large urban centres, smaller cities, cross-border cases. This latter is important to highlight as frequent travel across borders are an everyday occurrence. In several cases, especially on continental Europe, even daily commutes can be cross-border, as workers may choose to live in a nearby country to save money. Real life experiments as well as stated preference experiments can help determine users' willingness to pay for products and potential modal changes resulting from MaaS.

3.5 Policy Framework

The final pillar, policy, is the overarching umbrella that enables the system to operate in a fair, transparent and effective manner. In order for the whole MaaS concept and this framework to materialise policy, standards and regulation are needed to enable the market and protect the actors. Its importance cannot be underestimated. As MaaS is based on integration and interoperability, which are only possible if there are regulations and standards governing them. The policy framework is made up of five cluster areas in

which guidance needs to be provided. These are (1) regulatory, (2) financing, (3) privacy and security, (4) passengers, and (5) technology and data.

As expected, the regulatory responsibilities are the largest element in this pillar. The regional regulations will govern each regional MaaS system independently, every scheme will be unique depending on the conditions in each environment. These will need to be adjusted to fit with the local regulatory environments. As the ultimate vision is to have a Globally Integrated Mobility as a Service system, global MaaS standards are included in the framework. This may seem very abstract and impossible to achieve, however, GSM (Global System for Mobile communications) networks are a prime example of how it is possible to make globally accepted and implemented technical standards [17]. These standards initially will most likely only be implemented on country level, but having standardised and interoperable MaaS systems all over a country is definitely a first step in the right direction. On a more local level, the part-taking service providers and the MaaS Operator will need to be regulated and licenced (touched upon above). This ties in with the concept of standards, as all the providers will need to abide to them and should only be able to receive and retain their operating licences if they accept and follow these. Furthermore, the regional MaaS Operator will need to meet certain criteria. One approach could be making a checklist of characteristics and benchmarks (e.g. security standards, interoperability, sustainability of the system etc.) that MaaS Operators need to meet before they can be licenced to operate.

The second cluster included in the policy framework pillar is financing. As MaaS systems have the potential to be an environmentally and socially sustainable alternative to private vehicles [6], providing tax reliefs to these services can be a policy model that is worth exploring. Further, discounted MaaS packages – similar to current discounted public transport passes, should be offered to support social inclusion and overcome mobility inequality. There are many financing structures that need to be explored, including innovative ones like crowed funding, but these are out of the scope of this paper.

Third, privacy and security policy are a critical element to the framework. The success of the MaaS concept relies on the real time transfer of highly disaggregated information. If there are not proper privacy and security measures in place for both the demand and the supply sides, the system will break down. Further, the legal implications or any security breaches need to be outlined in policy, to make sure there is adequate enforcement of any privacy and security related violations. These standards/requirements also need to be made known to all affected parties. Fourth, passenger rights have to be addressed. As users will enter into legally binding contracts with the MaaS Operator, consumer protection regulations need to be applied. These are similar to those currently exercised for various transport service providers, for example flights or rail. Policies in this area can be adapted from those that currently regulate the individual services. These include, models for compensation if the service provided does not meet the expected standards, or if for any reason the user is denied access to any of the services. Further, users will only be willing to contribute significant amounts of information, if their privacy remains intact. Finally, technology and open data policy round out the pillar. The above discussed interoperability and open data play a crucial role. Both of these can be expedited by creating regulations, standards and policies.

As illustrated, the policy environment taps into every element of the MaaS ecosystem as such is an extensive topic for future research. Only through regulations, standards and policies can a safe, reliable and effective service be created that is available for all.

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 Mobility as a Service concept while exploring a holistic theoretical framework for 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 mobility service providers' offerings are aggregated by a sole MaaS Operator*, 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 ITS in the functioning of MaaS systems.

In the development of the MaaS ecosystem, four pillars were identified whose interplay creates the complex networks and interactions between the part-taking agents. It has to be noted, that the presented reference architecture is no way exhaustive. The demonstrated building blocks could each be the catalyst for further detailed research on them individually as well as the interactions and interplay between them. For future research we advocate the value of a systems approach, where the synergies can be incorporated into the analysis. Even though this examination only grazes the surface of the intricate MaaS ecosystem, hopefully it can be used by researchers and decision makers as a foundation for future MaaS research and development.

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