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Transport Research Arena (TRA) Conference

The MaaS concept in the field as of 2021: Typology of implementations based on an international panorama

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Abstract

MaaS (Mobility as a Service) is a recent concept embodying the integration of different transport modes and services via a single user interface which unifies one or several out of the following commercial functions: planning, booking, payment, and ticketing. This article seeks to develop a framework for MaaS analysis and present a panorama of MaaS initiatives in the Northern hemisphere as of 2021, in order to understand the practical meaning behind the MaaS concept. The analysis framework is based on a literature review of previous MaaS definitions and involves seven facets. The panorama of initiatives contains 30 implementations, of which 17 are out of Europe – from North America to Eastern Asia. From the characterization of the different initiatives, by conducting a cluster analysis, we derive a novel typology of MaaS initiatives in 6 categories.

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Keywords: Mobility as a Service (MaaS); MaaS characterization; MaaS integration scale; Implementation survey; MaaS typology; Regional specificities.

1. Introduction

In the last two decades, the development of information and communication technologies and the spread of the internet have deeply impacted the urban mobility landscape, enabling real-time multimodal geographic information, the democratization of smartphones among transport users, and digitalization of the commercial process of mobility transactions through platforms such as mobile apps and websites. These developments have enabled the rise of shared mobility services: car-sharing, ride-hailing, ride-sharing, etc. In turn, the concept of MaaS (Mobility as a Service) has emerged, as a way to bridge the gap between various public and private mobility service providers.

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Beyond theoretical conceptualization and actors' declarations of intentions, we seek to explore MaaS in practice as of 2021, with the aim of uncovering the concrete meaning that substantiates the concept of MaaS. As both the concept and the implementation initiatives have been developing in recent years, our work is rooted in contributions pertaining to defining and conceptualizing MaaS (Arias-Molinares and García-Palomares, 2020; Durand et al., 2018; Jittrapirom et al., 2017; Sochor et al., 2018) and in previous panoramas of various MaaS initiatives (Esztergár-Kiss et al., 2020; Jittrapirom et al., 2017; Kamargianni, 2015; Qin and Wang, 2020). In turn, this article has a twofold aim: developing the theoretical framework of MaaS analysis, as well as updating the panorama and enlarging its geographic scope. This leads us to propose a novel typology of MaaS initiatives.

We shall first conduct a brief literature review of MaaS definitions, tracing the evolution of the MaaS concept, and propose a MaaS analysis framework involving seven facets. We then explore different MaaS initiatives in Europe, the USA, China, Japan and South Korea, investigating the corresponding facets of each initiative. Next, based on the initiatives' description, a cluster analysis is conducted and yields a typology of MaaS initiatives in six archetypes. In the final section, we discuss the main findings of this study.

2. Characterizing MaaS schemes

2.1. Defining the MaaS concept

The concept of MaaS is relatively recent, and there is no unanimous definition. Thus, in order to identify the main aspects characterizing MaaS initiatives, we conducted a literature review of MaaS definitions as follows: in July 2021, the keywords "Mobility as a Service" and "MaaS" were applied to title, abstract and keywords within literature from Google Scholar and Science Direct. No restrictions were applied regarding, for example, date of publication or methods used. We rapidly excluded results that were not fully focused on MaaS (e.g.: computer science, mobile networks, etc.). Following a review of the identified papers' abstracts or, in cases where this was insufficient for determining a paper's relevance, the paper's content; we identified successive definitions which we deemed pertinent and representative of the chronological evolution of the MaaS concept.

First, some precursors of the MaaS concept have been traced to Meurer (2001)'s "individual mobility as a service" and UITP (2011)'s "integrated mobility". While these definitions mention some core aspects of MaaS, notably the service-oriented economic principles and individual mobility being uncoupled from private car ownership, they do not give yet any insight into the practical aspects required to achieve this combination. A first occurrence of the term MaaS itself was proposed by Heikkilä (2014). The author describes it as "a system in which a comprehensive range of mobility services are provided to customers by mobility operators". Soon after, organizational and technical elements such as 'one interface' and 'service provider' appear in definitions proposed by Kamargianni (2015) and Polydoropoulou et al. (2020). More recently, Alyavina et al. (2020), as well as Santos and Nikolaev (2021) have incorporated sustainability goals in their definitions of MaaS, putting the emphasis on the role of MaaS as an alternative to the usage of private cars. To sum up, Mobility as a Service (MaaS) is a recent transport concept which integrates different transport services, public and/or private, to provide travelers with a one-stop access to travel planning, booking and ticketing, and real-time information service through a common interface; generally with the ambition to help increase the sustainability of transport systems, mostly understood as replacing private cars.

2.2. Analytical framework

Seven facets are considered relevant to describe a MaaS scheme and compare schemes among each other's:

- Transport modes/services: Transport modes included in a MaaS scheme can range from: public transport, taxi, car-sharing, ridesharing, bike-sharing, car-rental, demand responsive transport.
- Covered area: While MaaS is often associated with urban agglomerations, with a wide array of transportation modes available, it can also be envisioned in less densely populated areas, in which shared mobility services could be developed to constitute a more consistent offer of transportation. Other initiatives feature a nation-wide scope.
- Commercial formula (tariff options): Generally, a MaaS scheme offers its mobility services either through subscription to a mobility package or pay-as-you-go. The subscription option assumes that end-users pay a weekly,

monthly or annual fee and receive bundled services from several transport modes. The pay-as-you-go option charges users on a per-trip basis and according to the effective use of each mode composing the trip.

- **Business model:** In practice, MaaS requires the cooperation of multiple actors from both the public and the private sectors. The relationships between actors, organizational structures, and revenue allocation models give rise to specific business models. UITP (2019) identified three typical business models for MaaS: (1) The “open back-end platform” (OBP) model is run by a public entity with rules set by the public authority and serves as public infrastructure on which different actors could build a MaaS solution. (2) The “transport as the integrator” (TI) model is run by the public transport operator without the support of external IT services, which sets the rules for the joint operations with other public or private transport operators. (3) The “commercial integrator” (CI) model has primarily private MaaS operators with a strong IT basis to support commercial operations.
- **Main goal:** ambitions can range from achieving sustainable mobility through modal shift away from private car, combining a variety of existing modes into a seamless multimodal service, improving public transportation accessibility by enlarging its coverage with public transit at its core, to boosting tourism and rural disenclaving.
- **Integration levels:** A few classifications of MaaS integration have emerged. We adopt the following 7 levels classification: (0) no integration, (1) integration of travel and tariff information, (2) integration of booking and/or payment, (3) integration of commercial formulas, (4) demand stimulation, (5) respective specialization, (6) production means pooling. The first four levels correspond those proposed by Sochor et al. (2018), and exhibit logical expansion of cooperation between the operators, from joint access to their respective service to joint packaging per trip, up to joint packaging beyond the single trip. Level 5 exhibits reinforced cooperation between the operator through demand stimulation via incentives, which may have societal or business motivations. Level 6 and 7 involve production cooperation beyond commercial functions: level 6 requires specializing each particular mode on a specific domain of relevance, defined with respect to the array of modes in the MaaS scheme, while level 7 involves a pooling of the means of production (vehicles, drivers, parking spaces, etc.).
- **Positioning in the general consumption market:** This facet assesses MaaS’ openness to ecosystems larger than mobility. Indeed, outside of the transport operators, other companies could also be envisioned as part of an enlarged MaaS ecosystem. For example, a subscription packages could also include free Wi-Fi access while travelling, free access to newspapers and magazines, movies or music. Furthermore, MaaS could be envisioned as part of a wider City as a Service initiative; incorporated into a larger “all in one” app that would provide seamless interaction with all kinds of services, encompassing mobility as well as leisure and tax payment etc.

3. International panorama of MaaS initiatives

The trajectory of MaaS may not be the same between different countries, since these are characterized by different settings and different specific challenges, perspectives and possible solutions. We aim to offer an overview of MaaS’ state of development through different regions of the world: Europe, the USA, China, Japan and South Korea.

In order to get an overview of relevant MaaS initiatives around the world, a wide range of literature (Arias-Molinares and García-Palomares, 2020; Durand et al., 2018; Jittrapirom et al., 2017) was used. As most publications tend to focus on European MaaS initiatives, information about non-European MaaS initiatives was searched for by a specific review conducted in July 2021: for each region, the keywords “Mobility as a Service”, “MaaS”, as well as the name of the region were applied to title, abstract and keywords on Google Scholar, with no specific restriction regarding date of publication (Lucken et al., 2019; Qin and Wang, 2020; Shaheen and Cohen, 2020; Zhang and Ning, 2021). In addition, a similar process was applied on the Google Search engine in order to construct a webography, available in appendix, consisting of white papers (e.g. (WEF, 2021)), press releases (e.g. (JR East, 2020)) and reports (e.g. (Global Mass Transit, 2020)). Only initiatives fitting the definition stated in the previous section were considered: e-ticketing and smart routing initiatives not integrating at least two modes were dismissed. From that exploration, on the basis of its website information, each initiative was described according to the 7 facets identified and summarized in the table 1.

Table 1: International panorama of MaaS implementations

MaaS initiative	Country	Covered area	Transport modes/services	Fare formula	Business model	Main goal	Integratio level	Market openness
Wienmobil	Austria	Urban	PT, bike sharing, car sharing, taxi, parking, scooter sharing	PAYG	OBP	Seamless MM	2	Open
Mobility Shop	Germany	Urban	PT, carsharing, taxi, bikesharing	PAYG	TI	PT acc	2	Limited
Qixxit	Germany	National	PT, taxi, carsharing, bikes, plane	PAYG	TI	Seamless MM	1	No
REACH NOW	Germany	M-urban	PT, carsharing, ride hailing , bikesharing, scooter sharing	PAYG	CI	Seamless MM	2	No
NS Lab app	Netherlands	National	PT, sharing of scooters / cars / bike	PAYG	TI	PT acc	2	Limited
Min Rejseplan	Denmark	National	PT, DRT, taxi, plane	PAYG	TI	PT acc	2	No
Mycicero	Italy	National	PT, parking	PAYG	CI	PT acc	2	Limited
Compte Mobilité	France	Urban	PT, carhsaring, bikesharing, parking	PAYG	TI	Seamless MM	2	No
Moovizy	France	Urban	PT, DRT, carsharing, bikesharing, taxi, carpooling, parking	PAYG	TI	Seamless MM	2	No
Assistant SNCF	France	National	PT, carsharing, bikesharing,taxi, ridehailing, scooter sharing	PAYG	TI	PT acc	2	No
Ubigo	Sweden	Urban	PT, bike sharing, car sharing, car rental, taxi	bundles	CI	Seamless MM	3	No
Travis	Sweden	Urban	PT, car sharing , taxi, scooter sharing, ride sharing	PAYG	TI	Seamless MM	2	No
Whim (Helsinki)	Finland	Urban	PT, bike sharing, car sharing, taxi, scooter sharing, car rental	bundles	CI	Seamless MM	3	No
SHIFT ^{1 2}	Usa	Urban	Bike sharing, car sharing, taxi, collective DRT, valet parking	bundles	CI	Seamless MM	3	Limited
Uber Transit ³	Usa	Urban	PT, ride hailing, bikesharing, scooter sharing	PAYG	CI	PT acc	2	No
GoPass ³	Usa	Urban	PT, bike sharing, car sharing, DRT	PAYG	TI	PT acc	2	No
ViaTransit ³	Usa	Urban	PT, ridehailing	PAYG	TI	PT acc	2	No
TriMet OTP ³	Usa	Urban	PT, bikesharing, ridehailing, carsharing	PAYG	TI	Seamless MM	1	No
WeChat ⁴	China	M-urban	PT, car sharing, car rental, bike sharing, taxi, parking, ridehailing	PAYG	CI	Seamless MM	2	Open
Amap ^{5 6}	China	Urban	PT, ridehailing, bikesharing, plane	PAYG	CI	Sust mobility	1	Limited
Maishi Mobility ⁶	China	Urban	PT, bike sharing, DRT	PAYG	CI	Seamless MM	2	Limited
Didi	China	M-urban	PT, car sharing, carpooling, bike sharing, taxi, ridehailing	PAYG	CI	Seamless MM	2	Limited
T-money	Korea	M-urban	PT, taxi	PAYG	TI	PT acc	2	Open
Kakao T	Korea	M-urban	PT, ride hailing, bike sharing	PAYG	CI	Seamless MM	2	Limited
My Route ⁷	Japan	M-urban	PT, taxi, carsharing, bikesharing	PAYG	CI	Seamless MM	2	No
Ringo Pass ^{8 9}	Japan	M-urban	PT, taxi, bikesharing	PAYG	TI	Seamless MM	2	Open
Willers MaaS ^{9 10}	Japan	Rural	PT, taxi, car rental	PAYG	TI	Tourism boost	2	Limited
Choisoko ⁹	Japan	Rural	PT, DRT	PAYG	TI	Rural	2	Open
MaaS Tech ^{10 11}	Japan	Urban	PT, taxi	PAYG	TI	Tourism	2	Open
Kozoji ¹⁰	Japan	urban	PT, DRT, taxi	PAYG	TI	Rural	2	Open

¹ (Kamargianni et al., 2016) ; ² (Lindsay, 2014) ; ³ (FTA, 2021) ; ⁴ (Vöge, 2021) ; ⁵ (GIZ, 2021) ; ⁶ (Zhang and Ning, 2021) ; ⁷ (Japan Voice, 2020) ; ⁸ (JR East, 2020) ; ⁹ (WEF, 2021) ; ¹⁰ (Global Mass Transit, 2020) ; ¹¹ (Highlighting Japan, 2021).

3.1. Cluster analysis

In this section, we conduct a cluster analysis in order to create typical clusters of MaaS initiatives. First, in order to assess the clustering tendency, Hopkins statistics were applied to the dataset. Then, the HCPC (Hierarchical Clustering on Principal Components) clustering method was used on a dataset summarizing the panorama of MaaS initiatives explored in the previous table. HCPC is an approach that combines factorial analysis (i.e. a principal component method) and hierarchical clustering, as complementary tools to explore the dataset. Having a mixed dataset, we first performed a FAMD (Factor Analysis of Mixed Data), then applied the cluster analysis on the FAMD outputs. As such we went from analyzing mixed-type variables to analyzing continuous variables, allowing us to perform a hierarchical clustering, which we then validated using a silhouette plot, in order to evaluate the goodness of the clustering structure.

Let us subject the set of surveyed MaaS initiatives to cluster analysis; using the factoextra package (Assambara and Fabian, 2020) in statistical computing software R. We start by conducting the FAMD on our dataset. By examining the eigenvalues, determine the number of principal components to retain: we retain the first 5 dimensions, which explain 74% of the variation among observations. Then, before conducting a hierarchical clustering, we assess the general clustering tendency of the data, by using the Hopkins statistic H . The factoextra package implements the complementary indicator $H = 1 - H_{\text{factoextra}}$. In our case, $H=0.177$, showing that the MaaS initiatives are indeed remarkably apt to be clustered. Applying a hierarchical clustering on the five dimensions retained leads to the creation of 6 distinct clusters, as shown in Fig. 1 below.

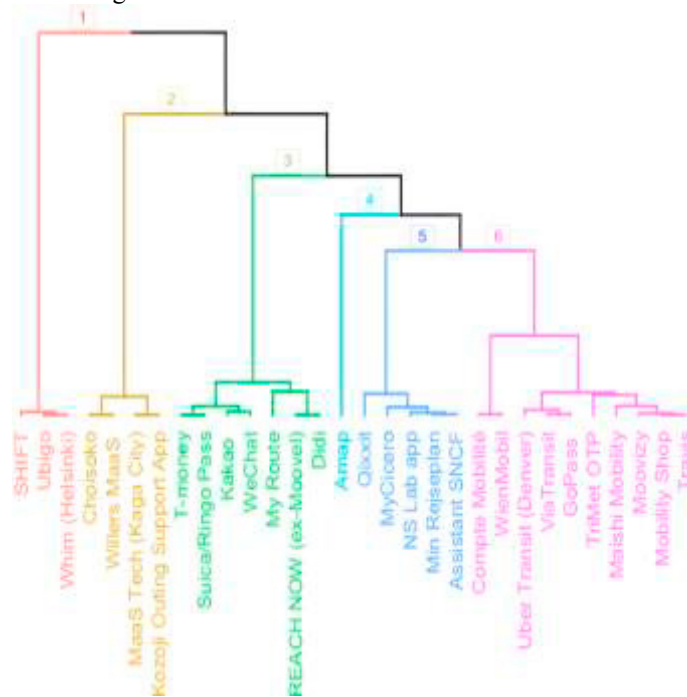


Fig. 1. Cluster dendrogram.

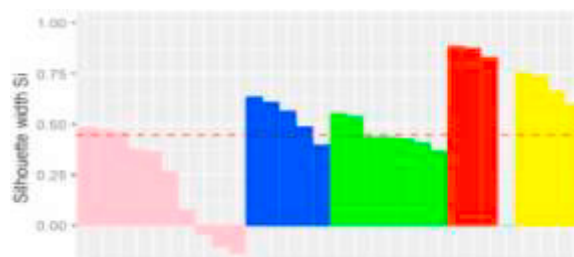


Fig. 2. Silhouette plot of the clustering.

We conclude by conducting an internal validation of the clustering process in order to evaluate the goodness of the clustering structure. The clustering results can be described with the silhouette plot, featuring the average silhouette width of each cluster, as shown in Fig. 2. The silhouette plot showed an average value of 0.45 for the whole clustering, which was a moderately good result. In addition, it is depicted that several initiatives reached high values; and the vast majority initiatives are well categorized (few negative values). Moreover, only two clusters have silhouette width lower than average. The first cluster with a low silhouette width is an atypical cluster that contains only Amap (cluster 4). This can be explained by the fact that Amap is an initiative which features a low integration level compared to other initiatives led by a commercial integrator, while also having a low level of openness to the general consumption market unlike Super Apps. Not resembling any of the other initiatives, the automated clustering naturally kept Amap as a standalone cluster. The other cluster featuring a lower than average silhouette width is cluster 6. In addition, its size is notably bigger than the other clusters (10 observations out of 30 in total). We argue that this cluster can be further divided into two distinct categories. In fact, while all observations show similarities on many facets (operating in urban areas, integration level equal to 2, many transport services included, low openness to the general consumption market), a major distinction resides in the main common goal: integrating a wide range of existing mobility services versus improving the accessibility to mass transit.

3.2. Proposed typology

Based on the clustering results and its internal validation, we posit a typology of MaaS initiatives in 6 archetypes, namely: Adhoc (based on cluster 2), Super app (based on cluster 3), National platform (based on cluster 5), Local: intermodal (based on cluster 6), Local: multimodal (based on cluster 6), Pure player (based on cluster 1). Table 2 features out the archetypes according to the framework facets and provides their subsets of surveyed initiatives.

Table 2. Proposed typology of MaaS in 6 categories.

Archetype	Adhoc	Super app	National platform	Local: intermodal	Local: multimodal	Pure player
Main geographic regions	Japan	Asia	Europe	USA, Europe	USA, Europe	Northern Europe
Examples	Willer MaaS, Choisoko, MaaS Tech	T-money, Suica, Wechat, Kakao T, Amap	Assistant SNCF, MyCicero, Qixxit, NS lab app	GoPass, Via to Transit, Uber transit, Mobily Shop	Trimet OTP, Compte Mobilité, REACH NOW, MyRoute, Didi	Whin, Ubigo, SHIFT
Covered area	Rural	Multi-urban	National	Urban	Urban	Multi-urban
Modes/services	+	+++/+	++	++	+++	+++
Commercial formula	No bundling	No bundling	No bundling	No bundling	No bundling	Bundling
Business model	Transport as the integrator (Taal)	Commercial integrator / Taal	Transport as the integrator	Commercial integrator / Taal	Open back-end platform / Taal	Commercial integrator
Main displayed goal	Rural/tourism	Wide integration of mob. services	Improving PT accessibility	Improving PT accessibility	Wide integration of mobility services	Wide integration of mob. services
Integration level	2	2	2	2	2	3
Market openness	Y	Y	N	N	N	N

4. Discussion and conclusions

4.1. General discussion

At the theoretical level, the proposed MaaS analysis framework features out seven facets, notably the positioning in the general consumption market, an aspect which had so far been missing from MaaS related research. We also developed the integration scale by introducing additional levels pertaining to strong coupling between operators'

production processes: yet none of the initiatives surveyed so far seems to involve such strong linkage. By applying the analytical framework to 30 different MaaS initiatives around the world and clustering the resulting descriptions, we revealed six archetypes. As it involves multiple criteria, this classification is more complex than previous ones revolving around a single dimension, be it integration level (Sochor et al., 2018) or business model (UITP, 2019).

The panorama of MaaS initiatives covers a wider geographic scope than previous similar studies, since it includes initiatives in the USA, China, Japan and South Korea. In fact, the variety of initiatives contradicts the common belief that MaaS is mostly a Europe-centric concept of little relevance abroad. Moreover, looking at the geographical repartition of the six archetypes through their practical instances, it appears that the development of MaaS presents geographical specificities. Indeed, initiatives of the same regions share many similarities and tend to belong to the same archetypes. In addition, the anchorage of archetypes is uneven across the world: while Super apps are common in Asia, Adhoc MaaS has strong support in Japan and Pure players originate mostly from Northern Europe. Even when an archetype is found in two different geographic regions, distinctive specificities do emerge in each region: while Local (intermodal) MaaS is present in both Europe and the USA, it is led by the public transport operator in Europe as compared to mostly PPP in the USA. Similarly, while Local (multimodal) MaaS is present in both Europe and the USA, the former distinguishes itself by its environmental focus.

Finally, looking at the state of progress of the observed initiatives undermines the depiction of MaaS as a universalizing tool for mobility. Indeed, while the MaaS concept is rapidly spreading and new initiatives see the day, most initiatives display low levels of integration and as yet, only two MaaS initiatives operate at integration level 3 of shared commercial formulas: Whim (Finland) and Ubigo (Sweden). In particular, “Super apps” integration of MaaS features is still parceled despite an often long-standing history of transactional integration (payment and ticketing), while “Adhoc MaaS” are still at early stages of development (deployment of “Adhoc MaaS” pilots is limited and very recent). This raises the question of whether MaaS will evolve to further meet the ambitions imputed to it by its theoretical conceptualization, including the alignment with societal goals through demand stimulation (integration level 4) and production synergies (integration levels 5 and 6), or will simply settle as a commercial tool.

4.2. Limitations

The panorama of MaaS initiatives and the subsequent cluster analysis leading to the proposed typology present 3 types of limitations: First, as MaaS becomes more and more popular and thus widespread, the current data could become outdated very quickly as new initiatives and trends emerge. This paper can be considered as a review of the current status of MaaS, which might be extended with new initiatives in the (near) future. Second, considering the wide geographic scope of the data collection, difficulties emerge due to language considerations since English might not be the preferred language in which MaaS initiatives are explored in different countries. Therefore, initiatives which are out of the view of the authors are not listed. In an effort to tackle this issue, we include a wide range of second-source data in our review of MaaS initiatives. However, this analysis should not be seen as including all available services in the world but rather as an overview of available MaaS applications. Third, regarding the clustering data-driven approach, it should be recognized that an error in data collection (e.g., identification of an initiative’s characteristics) might cause bias in interpreting the results.

4.3. Conclusions

The gist of the paper was to explore MaaS initiatives in countries around the world to better understand the concrete conditions underpinning the MaaS concept. This exploration is based on a renewed analysis framework that builds upon previous MaaS definitions and reviews of MaaS implementations. The subsequent panorama examines 30 MaaS initiatives, 17 of which are non-European initiatives located in the USA, China, Japan and South Korea. Based on this panorama and through a cluster analysis, we revealed six MaaS archetypes, namely: Adhoc, Super app, National, Local (intermodal), Local (multimodal), and Pure player.

Further work may be conducted by extending the geographic scope of our analysis to include developing countries in the Southern hemisphere, as well as other developed countries such as Singapore, Australia and New Zealand. Another direction for further research pertains to MaaS simulations and their methods: indeed, simulation studies contribute to MaaS development and spread by enabling the ex-ante estimation of potential outcomes from a MaaS

initiative and how well they fit within the involved parties' ambitions. As such, a critical review of MaaS simulation methods would prove a valuable complement to the review conducted in this article.

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