Innovative Business Architectures (BAs) for Mobility as a Service (MaaS) – exploration, assessment, and categorization using operational MaaS cases

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ABSTRACT

Transport service provisions, especially in the developed countries, are immensely changing due to technological innovations and the influence of information and communication technology (ICT). Particularly, the evolution of ICT is breaking down the boundaries between different transport modes allowing for integrated mobility rather than individual services. Integrated mobility services can take various forms and can be delivered in several ways. In other words, there can be different versions of Business Architectures (BAs) with dis/integration of services at various levels and to several degrees. This paper extends existing literature regarding the MaaS on different BAs by considering the critical dimensions in provision of these new mobility services. A classification of these BAs is presented, based on two critical elements: 1. integration of mobility services by one/multiple suppliers, 2. integration/disintegration of distribution and marketing channels (D&M). The results indicate that integration vs. disintegration (either services or D&M channels) depend on the types of services and strategic behaviors of transport operators and distributors. If the services are complements/substitutes as in mobility chains, integration/disintegration is advocated. Disintegration/integration of D&M has higher payoffs in the strategic substitutability/complementarity. Additionally, the benefits and drawbacks of these BAs are investigated from both transport operators and travelers' perspectives. Finally, eleven case studies of MaaS are studied to demonstrate the outcomes of the theoretical analysis. This paper broadens the perspectives on organizational structure of MaaS for both academics and practitioners.

1. INTRODUCTION

The ubiquitous availability of digital information allows firms providing mobility services to deal with rapidly fragmented flexible lifestyles with fast varying needs for transportation. This is translated into an increasing need for demand-driven mobility services as opposed to scheduled public transit. These demand-driven trends can potentially bridge the gap between public and private transport operators[1] and can create integrated and effective mobility systems potentially increasing the use of Public Transport (PT) and ride sharing. At the same time, they offer new opportunities for PT management opening new doors to cope with the increasing budgetary challenges of operating on low-frequency low-demand transit routes.

A popular example of such new mobility systems is "Mobility as a Service"(MaaS)- an innovative concept that has recently emerged to offer door-to-door mobility services *(1)*. MaaS potentially enhances accessibility and efficiency of transport systems by identifying more deeply the supply and demand patterns. MaaS is believed to provide sustainable and user-centric services and to offer unique opportunities to bundle (latent) travel demand, to organize the smart use of existing systems and support orchestrated and/or self-organizing innovative travel services in which an interface automatically matches travelers' demand and supply *(2)*.

Notwithstanding the advantages to travelers of an increased number of options provided in MaaS, the question is how to design the Business Architectures (BAs) of such complex integrated systems, on the one hand examining organizational and governance structures for transport operators and increasing the role of firms offering flexible mobility services, on the other. The present paper intends to fill this gap in the current literature by addressing the critical dimensions in provision of innovative integrated mobility services. Meurs & Timmermans *(3)* explored MaaS as a multi-sided market and the features and challenges are discussed for successful implementation of Multi-Sided Platform (MSP). A crucial feature of MSP is the network externalities. If the number of car sharing entities increases, the platform will be more attractive for other entities (direct network effect). By increasing the number of car shares, the travelers' utility will increase due to more options being provided by the platform (indirect network effect). Two challenges need to be overcome for the business continuation of the platform: 1) Getting both suppliers and demanders to the platform, and 2) Achieving the sufficient number of users. Fitting to these characterizations, in this study, this type of BA is elaborated on and more varieties of BAs are evaluated. Kamargianni & Matyas *(4)* defined the business ecosystem by introducing multiple actors, their roles and the relations with MaaS providers. One of the main differences of MaaS is a new approach to distribution channels[2]. Recognizing this, in this paper, multiple types of Distribution and Marketing (D&M) channels are studied. König et al. *(5)* analyzed multiple operator models and the business models of MaaS. Four different models are presented, describing the organizational structure of MaaS including reseller, integrator, PT operator and PPP models based on who holds control over the integration of mobility services. Different models are appropriate for different geographical levels of mobility services such as urban, suburban areas, national, international levels. For instance, the reseller model might be best for national and international travelling (e.g. travel agencies). Integrator model is suitable for multiple levels including urban, suburban areas and national/international. In current paper, the applications of multiple BAs are evaluated in different cities/ countries.

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[1] Definitions

1)Transport operator: the main supplier of transport services. i.e. an entity that produces transport services.

2)MaaS (service) providers has full control over the integration of mobility services, i.e. an entity that connects the operators and travelers.

[2] The main functions are service customization, service availability, physical distribution, and transaction (14).

This paper adds a thorough investigation of potential BAs and the crucial dimensions that motivate the choice among different BAs to the literature, specifically the choice to integrate mobility services within one firm, and the choice to (dis)integrate the control of D&M from the supply chain (SC) are discussed (section 2). Based on this analysis, typologies of MaaS-BAs are established identifying their corresponding strengths and weaknesses (section 3), followed by a demonstration of operating MaaS systems to the classification of BAs (section 4).

2. EXPLORATION: MAAS BUSINESS ARCHITECTURES

The BAs are designed by defining the roles of multiple actors. A distinctive approach is followed in this paper in exploring BAs. At first, the crucial dimensions in provision of MaaS are identified, and then BAs are designed and classified based on these dimensions.

2.1 Crucial Dimensions

To begin the discussion on BAs and the choice processes, an exploration of the critical dimensions that might mandate the choice is crucial. In MaaS, one major dimension is whether transport operators should integrate the mobility services within one firm allowing for integrated decision making with respect to the provision of these services or adopt more independent provision of individual services with an intermediary that links the services while individual firms optimize their individual supply processes. Another dimension relevant for MaaS is whether the distributions of these services should be done by the firms providing the services (vertical integration of the D&M function within SC or by an independent platform[1] (decentralized D&M). In many sectors (tourism, etc.), the external D&M channels are removed because they could not continue competition with internet types of D&M channels established by suppliers (a process called dis-intermediation) *(6)*. Contrary to these developments, with MaaS one is adding an additional (actor) layer between the transport operators and the travelers, viz. the digital platforms, in most cases providing an app. MaaS providers perform like the electronic intermediaries and, the mobile apps and websites might be used to plan and book (door-to-door) trips taking multiple options into account. These digital platforms might be complementary or substitutive to current D&M channels of operators *(7)*. The business rationale for this alternative D&M for multimodal transport services is not straightforward since the additional costs should be lower than potential benefits.

Hence, in establishing a BA for MaaS, two key questions are relevant:

a) whether the transport operators should supply integrated services or provide individual services to be integrated by an external platform?
b) whether they directly distribute and sell their services or involve a third party to control over the D&M?

With respect to the first question, the results of a number of studies are used to investigate the appropriate strategies for the complement and substitute products/services to produce within one or by multiple firms *(8)*. Two modes are complementary if the sequential uses are either essential or simply more desirable than single mode for a journey, and they are substitutes, if travelers can only use one of the modes. The strategy of the operators is well-known in the presence of perfect complement and substitute services. If the mobility services are complements, then integration (cooperation) of different services within one firm is an

[1] The central element of MaaS needs a platform that provides mobility services across modes *(5)*. Technically, integration of services may be realized by using so-called platform technology, which facilitates interactions between travelers and transport operators in an improved or smarter way. The platform enables the aggregation of services and information and delivers a certain price for the end-users. Platforms create value by coordinating these services through providing information about prices and qualities of services *(35)*.

appropriate strategy due to lower prices, and if they are substitutes, the mobility services are better to be supplied by independent operators in a competitive market. As an example, in mobility system, the shared taxi, and bike are complements to PT services in the transport network wherever no PT services are available; these modes serve as access and egress modes. However, these modes may also compete (substitute) with PT and integration within one firm may decrease competition. The critical question is which strategies are appropriate in case of non-perfect substitutes and complements services, prevailing for many mobility services. Givoni & Banister *(9)* examined the cooperation, competition, and integration between aircraft and high-speed train (HST). These two modes are substitutes in some routes and complements in others. Based on the evidence, the HST won in competing routes by offering the same or shorter travel times. In areas that airport is in the suburb, HST is a complement service for airline and the two operators are providing the complementary services but the real cooperation did not take place. The actual cooperation is when the HST and airplane are decided to integrate and provide a complete journey with a rapid and smooth transfer between modes. Based on their investigation, in case of imperfect complement or substitute, the cooperation is more beneficial than competition[1] and the most important benefits are the environmental impacts and time savings for travelers.

With respect to the second question, two important aspects need to be investigated:

1. *whether the transport operators and/or travelers have benefits in using an external D&M which compensate for additional costs?*

In the transport system, few examples exist[2]. However, it can help to simplify the analysis and provide insights on the external D&M. Car rental companies such as Hertz, Avis, Budget, and Europcar act as a pure external D&M. They buy or lease some vehicles and rent them to the clients. Intermediaries should provide values both for travelers and transport operators. The literature is reviewed that investigates the integration of D&M or an alternative one, assigning an external firm to manage the D&M *(10, 11)*. Results of these literature show that full control over the D&M are not always the best strategy, and the firms can acquire benefits even by paying extra costs of intermediaries (responsible for managing D&M).

The intermediaries have specific advantages, probably higher knowledge about the existing transport services, better user interface, and a complementary benefit to better provide mobility services based on travelers' needs. The intermediaries sometimes provide the services with the same prices and in this way, the travelers do not consider the intermediaries' costs. For instance, an airline who sells the tickets with the same prices both for the travelers that directly buy services or via travel agencies *(12)*.

It has been shown that providing services directly to the end-users and possessing the D&M channel is negatively related to the substitutability of services *(13)*. The strategic behavior of suppliers are important factors in D&M strategy (11). An operator's action in one market (the consequences of the new strategy are shown in the marginal costs of the operator) can change the strategies of competitors. The consequence of this action depends also on the fact that other transport operators are strategic complements or strategic substitutes. In strategic complement, the operators mutually reinforce each other, and in a strategic substitute, operators mutually offset each other *(36)*. Disintegration (integration) of D&M has higher payoffs in the strategic substitutability (strategic complementarity). These studies mainly emphasize the role of D&M channels on the profits and prices of products.

2. *Whether a mix D&M channel is more beneficial?*

New types of D&M are introduced by ICT development and the alternative D&M model has not been studied yet, i.e., a combination of controlling D&M by transport operators and

[1] In contrast to economic literature which the competition is promoted to decrease prices.

[2] PT usually uses their own D&M[2] in combination with digital platform to interact with travelers.

platform providers. In mobility system, the internet based D&M channel is beneficial since the customization of mobility services, a frequency of usage, waiting time, time in a vehicle and convenient locations of services are important factors which can be easily provided using the mobile apps and websites *(14)*. In the tourism industry, the web did not reduce the number of intermediaries, but it has increased the complexity of D&M by adding additional layers. The consequences of this change for users are the complexity in buying process and potential loosing of direct interactions. The travelers might be frustrated by too many choices and feeling helpless in the absence of human interaction. These technological interfaces cannot completely take over the benefits of direct interaction. Transport operators and intermediaries should not stop the direct interaction to save costs with technology instead, they should use it to improve the interaction *(15)*.

The advantages of using internet are presented, using three functions within channels; 1. communication channel: e.g. enhancing the interactivity and feeling experiences, 2. transaction channel: e.g. increasing revenues by selling more services to the existing customers, 3. D&M channel: e.g. cutting down the SC and reducing the operating costs *(6)*. Transport operators might have higher shares of profits that are generated because of access to a larger network, especially for off-peak trips and the travelers take advantages of both lower prices and larger choices. These mix D&M channels as a result of ICT development can reduce the costs of D&M through the transaction scale economies *(16)*.

2.2 Business Architectures

Based on the crucial dimensions distinguished in the previous section, multiple BAs are designed to examine organizational and governance structure of MaaS. BA is used to show multiple ways to distribute responsibilities of business activities, e.g. production *(17)*. Additionally, the suitability of each BA based on the types of services (complements and substitutes) is explained. For platforms offering mobility services, multiple types of service provisions are distinguished which are defined and depicted in TABLE 1 and FIGURE 1 respectively.

TABLE 1 Definitions of Business Architectures for MaaS

BAs	***Descriptions***	***Feature***
VI_a**: VI of mobility services by the travelers* ***(the reference model)	Transport operators offer unique mobility services with an integrated distribution system, like the traditional PT or car rental firms. The transport operator has full control over the production, supply, and D&M. Regarding the terminology, the term 'vertical integration' refers to the integration of the production and distribution of services within the SC of each transport operator.	Full control over D&M
***VI_b:** VI of mobility services within multi-modal operator*[1]	The main difference is the provision of multiple types of services by one firm. The D&M are integrated into multi-service transport operators. The operator makes alliances with or possesses other transport operators. Examples are large PT operators that provide train, bus, and taxi services. NS integrates the train services with bike/car sharing (green-wheels car) and the travelers can pick up bicycles and green wheels' car from NS stations.	Full control over D&M Multi services by one firm
***INTP**: INTermediary Platform*	A specific service provider as an intermediary takes over services from distinct transport operators integrate them and sell them to travelers. Trainline.com is an example of intermediary which controls over the integration from multiple operators *(18,19)*. The D&M activities are done by intermediaries and not by transport operators. Walmart, Amazon, and Bol.com are examples in other industries.	No Control over D&M

[1] Multi-modal operator: an entity that performs the provision of more than one type of services such as bus and taxi.

***MSP**: Multi-Sided Platform*	The fundamental features are enabling the direct interactions between participants and affiliation of each side to the platform. The operators may remain responsible for important service features and pricing of these services and delegate the communication of services towards users to the platform. Affiliating with such a platform may be interesting for operators who may gain access to many potential users. Conversely, it may be interesting for travelers to affiliate since they can reduce search and information costs for an individual transaction. eBay and Google is a pure multi-sided platform like Uber, directly matching car owners with excess capacity with travelers *(20, 21)*.	Semi control over D&M

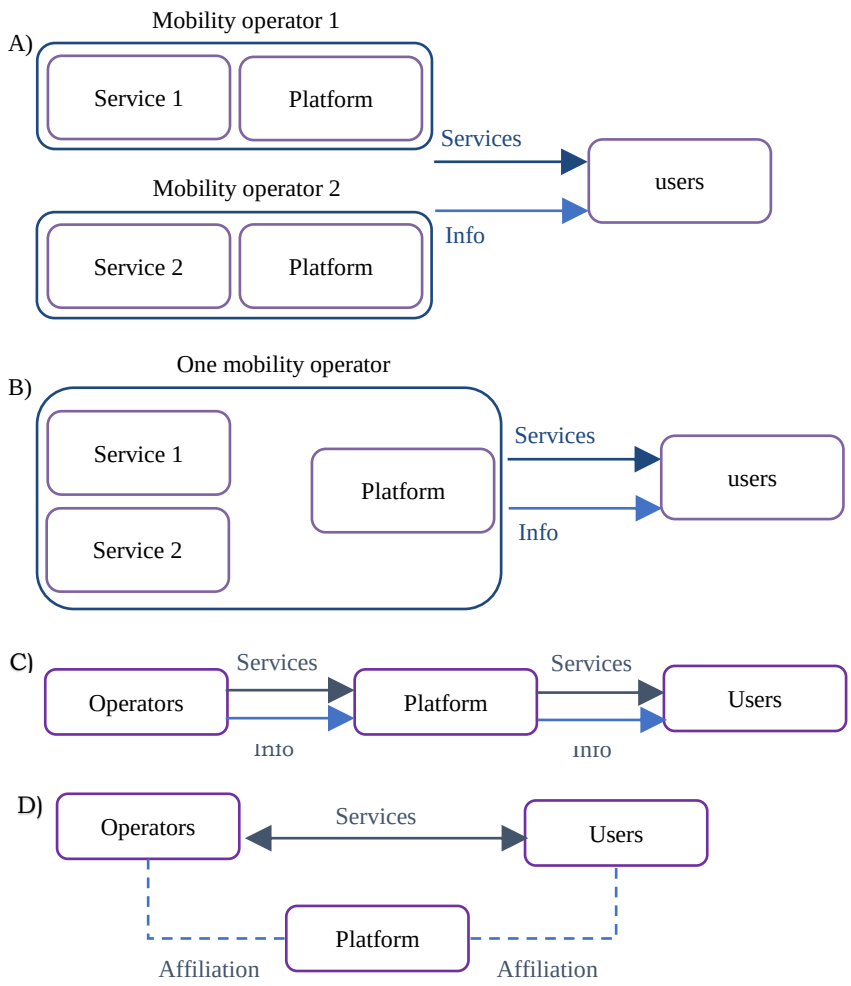

FIGURE 1 Business Architectures: a) Vertical Integration of Mobility Services by Travelers, b) Vertical Integration of Mobility Services within Multi-modal Operator, c) Intermediary Platform, d) Multi-sided Platform

The main features of these BAs are as follow:

a) VI_b: Integration of services within one firm and integration of D&M within the SC of transport operators are the crucial features. Thus, it may best fit when the services are complements or the operators reinforce the strategic behaviors of other operators/ distributors. The similar condition is applicable when the services are substitutes, but the transport operators support the strategy of other operators/ distributors.

b) INTP/ MSP: Disintegrations of services and D&M are the crucial elements of these BAs and best fit when services are substitutes and operators behave against the strategy of other players. Similar BAs might best fit when the services are complements but the transport operators offset the actions of other operators (FIGURE 2).

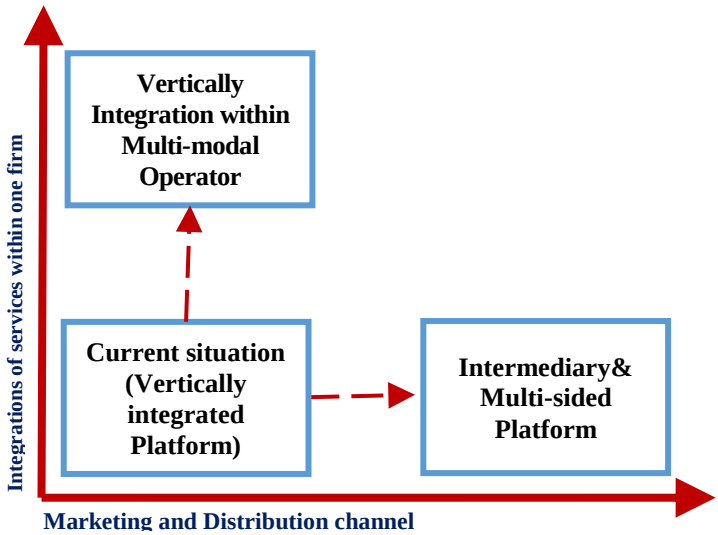

FIGURE 2 The Tradeoffs and Determinant Factors in Choosing each Business Architecture

3. ASSESSMENT: BENEFITS AND DRAWBACKS OF BAs

After designing BAs and finding out the arguments behind integration vs. disintegration, the consequences of using these BAs for travelers and operators are explored. These consequences are classified based on the crucial dimensions discussed in section 2.1.

3.1. Service Integration within one Firm

Multi-service operators have some benefits and drawbacks that need to be investigated. The transaction costs (search for alternatives, etc.) are lower for travelers and it might lead to higher trust and reliability. The multi-service operators are beneficial in cases of high transaction costs for products and services *(22)*. Additionally, they are more flexible when disruptions happen in the timetable of their services by shifting to other modes and they can increase the net gains by less duplication of costly investments such as sharing costs of D&M or using similar inputs such as labors, capitals, and energies *(23, 24)*. PT services are usually provided by monopoly or multi-service operators benefiting from economies of scope[1] and scale[2] *(25, 26)*. This type is suitable especially for PT services since allowing entry and cherry picking might threaten the realization of economies of scale in one specific region of mobility services. It also leads to oversupply which might not increase the social welfare *(27)*.

Multi-service operators are providing different services and coordination between their activities might be difficult and may lead to diseconomies of scale. The decision making is more complicated and takes longer because of larger scale. Furthermore, the integration of services is often more supply oriented rather than demand oriented. Provision of services are optimized using the transport operators' objectives rather than the travelers' need. In general, larger firms with monopoly power do not perform well in innovation that requires flexibility and matches demand pattern such as modifying the services for a specific group of travelers (28, 29). Multi-service operators have monopoly power and the potential of anti-competitive effects. Thus, some price regulations are required. These operators have more market power because of providing multiple mobility services and not because of more efficiency. Additionally, increasing the number of services within one firm on average reduces the profits of the operators *(24)*.

[1] Economies of scope exists, if the costs of producing more than one mobility service by one single operator is lower than producing these number of services by different specialized operators

[2] The cost of service production decreases if more users buy the services.

3.2. Integration vs. Disintegration of D&M Channels

There are some benefits and drawbacks in integration vs. disintegration of D&M both for the travelers and the transport operators. Travelers can have access to a larger network of suppliers by only one interface which decreases the search costs in time and money for travelers and they can use their times and budgets more efficiently. Besides, platforms provide online access to information with possibilities in tracking changes due to disruption in services. For instance, if disruptions happen in MaaS in the UK, the platform offers alternative mobility packages.

In VI_a and VI_b, travelers do not have to pay the extra costs of intermediaries especially for sharing mobility and car rental companies. Transport operators usually make the main investment in providing the digital platform and travelers need to learn how to use the platform. On the other hands, in INTP, travelers might buy mobility services cheaper, since the intermediaries purchase the mobility services at wholesale prices[1]. In MSP, they can directly communicate with suppliers and they usually have more choices of modes with different options of prices.

Like travelers, transport operators can have access to a larger network and new groups of travelers, especially important for smaller operators. It reduces the search costs but the transport operators should compete with similar mobility services to increase their market shares *(30)*.[2] Besides, if platform offers ticketing and payment system, it makes fare collection much easier for operators *(31, 32)*. The benefits of using platform might be different for PT and private providers. Joining a platform might not be beneficial for the PT providers, especially in a short-term period since they already have their market shares and it is impossible to enter the new market unless the infrastructure of supplying the PT services are provided. Therefore, the main benefit for larger scale transport operators is improving communication. The private companies which offering sharing mobility concepts might benefit since they do not have to make a huge investment for distributing their services *(33, 34)*.

In the case of INTP and MSP, the third parties enter the market and control over integration. They help to improve the coordination among operators and travelers. Additionally, the transport operators might reduce the high costs of building a D&M channel since the third parties can provide these services with lower costs because of economies of scale. These third parties might have less focus on the specific services in comparison with the D&M by a specific transport operator. In these BAs, the transport operators have less information and control over the travelers and they pay from their profit margin for the channel. A crucial feature of MSP is the presence of network effects. The direct network effect is the impact on the utility of users because of increase in the number of users on the same side of the platform. For instance, increasing the number of car sharing entities promote more participants since it makes a platform more attractive. The indirect network effect is the impact on the utility of travelers due to increase in the number of transport operators, i.e. if the number of operators increases, the platform is more attractive for users *(3)*.

[1] A phenomenon called "double marginalization' may arise when both the platform and the mobility providers are monopolists; in that case prices will be higher *(37)*.

[2] The term coopetition means to join in a platform and compete with other operators to sell the services *(38)*.

Table 2 The Potential Benefits and Drawbacks of BAs for Travelers and Operators

BAs	Shared Benefits	Specific Benefits	Drawbacks
VI_a	***Travelers*** • access to a larger network of transport operators • reduce the search costs (time and money) • possibilities in tracking changes ***Transport operators*** • access to a larger and new network of travelers • reduce the search costs (time and money) • reduce operating costs because of ICT development such as electronic check in • easier fare collections • PT providers: improve the communication; private providers: required less investment for D&M access to a larger and new network of travelers	***Travelers*** • no extra costs of intermediaries • more reliable in planning, booking, and payment ***Transport operators*** • Increasing the value-added surplus of transport operators through economies of scale • concentrating on the specific type of mobility mode • more control over the travelers	***Travelers*** • limited choices of mobility modes due to high costs, the provision of many services are not possible by one operator ***Transport operators*** • might require a huge investment • coordination might be difficult with travelers and other transport operators
VI_b		***Travelers*** • might buy services cheaper • expected to provide a higher quality of services to keep the market share of intermediaries ***Transport operators*** • Net gain of utilizing or sharing similar activities • more control over the travelers • Substantial reduction of intermediary costs • Covering the disruptions of one mobility modes by another one • Less cherry-picking	
INTP		***Travelers*** • both direct and indirect communication with transport operators • more modes and packages of services with different choice of prices ***Transport operators*** • improve the coordination among transport operators and travelers • might reduce the costs of D&M • network effects	***Travelers*** • disruption happens, travelers should contact the transport operators • difficult to make consumer trust ***Transport operators*** • the cost of intermediaries and payment to the third parties from the profit margin • less focus on specific type of mobility mode • less information and control over the travelers
MSP			

4. CATEGORIZATION: BUSINESS ARCHITECTURES OF OPERATIONAL MAAS CASES

After exploration and assessment of each BA, the types and features in operational MaaS cases are identified and explored; the benefits and drawbacks are also investigated. Some core features are selected to determine the type of BA, which reflected in the following questions:

1) Does a mobility operator provide more than one service? (Y/N)
2) Does the transport operator possesses and operates the platform? (Y/N)
3) Do both transport operators and travelers provide information including the feedbacks through the platform? (Y/N)
4) Does the third party buy the services from transport operators and then sell the services to the travelers? (Y/N)

The answers to these questions are mainly based on the definition in TABLE 1.

Type of BA	*Answers to questions*
VI_b	1,2=Y; 3*,4=N;
INTP	1,2,3=N; 4=Y
MSP	1,2=N, 3=Y, 4=N

*Transport operators provide information to the platform, and not the end-users. Only in MSP, both sides, operators and travelers, provide information through the platform.

Eleven case studies are studied to identify the type of BAs they exemplify. These are within Europe and some are international such as Masabi (US, EU) and Trainline (across European countries). In TABLE 3, the first column indicates who controls over integration which is mainly PT providers, transport authorities, and private companies. 36% of these BAs are controlled by private companies. The second column presents the mobility services. In almost all cases, PT is offered as part of mobility services. In 50%, bike sharing is provided.

The classification exercise shows that BAs can take pure and hybrid forms. The pure BAs are mainly VI_b and INTP. Among them, the VI_b is the most observed BAs, initiated by operators or public authorities. The INTP is mainly observed in providing one type of mobility service such as integration of train services within and between countries. Some case studies have the core features of more than one BA; (VI_b and MSP) or (INTP and MSP), categorized as hybrid BAs in this study. In the hybrid types, the integration is done by transport operators or public authorities, they also follow the feature of MSP, enabling the direct interactions of travelers and transport operators.

TABLE 3 BAs of MaaS in various cities/countries

Case Studies	**Integrator**	**Mobility Modes**	**Scoring Framework**				**BA**	**Continuity**
			1	**2**	**3**	**4**		
SMILE (AUT)	PT provider	PT, (e-)Bike & (e-)Car sharing, taxi, regional trains and ferry	Y/N	Y	N	N	VI_b	2014- May 2015
Seinäjoki Sito (FIN) MaaSito	Sito, transport operators, and municipality	Shared taxi and PT rides (DRT)	N	Y	N	N	VI_b	Feb 2016-May 2017
Hannover mobil (DEU)	Hannover PT operator, Ustra[1]	PT, taxi, bike and car sharing	Y	Y	N	N	VI_b	2016-present
Qixxit (DEU)	DB	All transport modes in Germany	N	Y	Y	N	VI_b	2016-present
Vienna mobile card (AUT)	PT-operator, Wiener Linien[2] (WL)	PT service (rail, subway, tramway, and bus), bike and car sharing, taxi	Y	Y	N	N	VI_b	1999-present
HSL mobile card (FIN)	Helsinki regional transport authority	PT, CityBike, Kutsuplus[3], car sharing and rental	Y	Y	N	N	VI_b	2010-present
SLIM (NLD)	Public authorities	PT services, car and bike sharing	N	Y	Y	N	VI_b & MSP	March 2017-March 2019
Masabi (GBR)	Private company	PT services including rail, bus, tram, and ferries	N	N	N	Y	INTP	2012-present

Thetrainline.com	Independent party, private equity	Mainly rain tickets and car hire	N	N	N	Y	INTP	1999-present
UbiGo (SWD)	Private company	PT, taxi, bike and car sharing, car rental	N	N	Y	Y	INTP & MSP	Six-month pilot (Nov 2013-May 2014)
Whim (FIN)	Private Company	PT, rental car, taxi, regional rail, (bike sharing, car sharing=planned)	N	N	Y	Y[4]/N	INTP & MSP	2016-present

[1] USTRA provides city buses and rails.
[2] Wiener Linien is a single firm providing PT services.
[3] More flexible than traditional PT and more affordable than a taxi. Instead of a taxi, a minibus picks up the customer from bus stop to bus stop.
[4] Background payment is always included.

TABLE 4 shows the benefits and drawbacks of existing MaaS, which is comparable to Table 2. However, there are some differences discussed as follows:

a) In the feature of VI_b, it was expected that fewer varieties of transport modes are supplied. However, it was not the case in the examples, probably because of the public authorities' regulatory and financial controls. Besides, the usages of PT services are increased by the provision of complementary services. Furthermore, some additional values are provided such as supplementary services.

For example, in MaaSito, the PT operators provide additional values, higher quality of PT services, by increasing time schedules and expanding routes. The information about cost is not very easily accessible. As expected, high investment costs are required for this BA, for instance, public authorities had to intervene in MaaSito. In Hanovermobil, the MaaS providers assign discount rate for car sharing and car rental. In Vienna Mobile, the MaaS providers enable the comparison of multiple routes based on the price and environmental impacts.

b) There are not many examples of pure INTP. The feature was not mentioned before that cases of INTP are more specialized in one type of mobility service such as railway in Trainline. Moreover, it was discussed in section 2.2 that intermediary might supply lower prices for users which was not observed in examples of pure INTP. In Trainline, they provide the same prices as transport operators but they find the cheapest one across multiple operators. Masabi helps PT operators to increase the sale capacity and reduce the costs of cash handling.

c) VI_b and MSP: one distinctive feature of this hybrid type is that it does not have the drawback of less focus on PT services (Table 2). For instance, the SLIM has the features of both BAs. The public authorities are the main initiators in integrations of services and PT operators are working under the supervision of the public authorities' rules and regulations. The integrator is involved in the provision of PT services and is not an external party. They hire an external party to provide the technology required for the digital platform. The information and feedbacks are received and delivered from travelers and operators through the platform.

d) INTP and MSP: Two case studies have the features of INTP and MSP. However, the integrators buy or pay in advance to the transport operators (the specific feature of INTP). In UbiGo, they can provide cheaper services depend on the increasing number of users.

UbiGo in Gothenburg and the Kutsuplus in Helsinki are failed to continue the operations. In UbiGo, they did not find a cooperative model that works best for PT and private operators and the Kutsuplus was too expensive for PT providers. In Hannover mobile, the discussion is about the integrator of services *(5).*

TABLE 4 The Observed Benefits and Drawbacks of Pure and Hybrid Forms of BAs

BAs	*Shared Benefits*	*Specific Benefits*	*Drawbacks*
VI_b	• integration of information, booking, payment and reducing the transaction costs • comparison of services based on multiple choices; routes, prices, and environmental impacts • the door to door mobility	• promoting the sharing concepts by discount rate to become complementary services for PT services • Increasing the quality of PT services by increasing time • providing supplementary services • increasing the usage of PT	• High costs • Some cases, less variety
INTP		• providing services across countries • finding cheapest services • reducing the costs of cash handling • increasing the sale capacity	• Less control by transport operators over • Payment from profit margin
INTP & MSP (UbiGo & Whim)		• larger number of travelers, lower prices • providing multiple packages	• Drawbacks of INTP+ less focus on specific type of services such as PT
MSP & VI_b (SLIM)		• benefits of VI_b + receiving and delivering of feedback and information	• Drawbacks of VI_b

5. CONCLUDING REMARKS

In this paper, four typologies of BAs are delineated based on an extensive interdisciplinary literature review. The economics and marketing literature are the precursors of transportation studies with respect to cost-effectiveness and D&M strategies. This research covers the primary BAs by identifying the crucial dimensions in the provision of MaaS, and then building the classifications, using these crucial dimensions.

The challenges are identified that transport operators are facing, which is the choice to (dis)integrate mobility services and the choice to (dis)integrate of D&M. Then the causes of integration vs. disintegration of services and D&M are studied using the literature review. Type of services and strategic behaviors of transport operators and distributors are important factors in decision-making regarding integration vs. disintegration.

These critical dimensions are used as a starting point for the classifying and designing multiple types of BAs. Afterwards, the benefits and drawbacks are investigated of the BAs from the perspective of travelers and transport operators. The important potential benefit of vertically integrated firms is enhanced reliability in planning, booking, and payment and the potential drawback is less variety in mobility modes, comparing to INTP and MSP. MSP is more customer-oriented and provide more varieties for travelers. In the last part, the BAs are identified for eleven existing MaaS case studies. In doing so, the four identified typologies can be assumed pure and hybrid forms, VI_b and INTP are two pure BAs, and a combination of MSP with VI_b and INTP are two hybrid BAs identified in the case studies. Any example of pure MSP is not found in the case studies. The most observed BA is VI_b. The INTP are observed in the case studies which are implemented across multiple countries.

The discussion in this paper points to the critical question that "what would be the strategy of the transport operators to deal with imperfect complementarity and substitution of services?" Regarding D&M, the knowledge gap is whether the operators follow mixed D&M channels, managed by transport operators, as well as through the technological platform. More research is needed into the decision-making regarding the integration of services within one firm and the role of external D&M channels either a pure external or mix-D&M channels. Modelling the behavior of stakeholders for multiple BAs is recommended for future research. The findings add new perspectives to the integration of mobility services and clarify the importance of selecting the appropriate BA, which is especially relevant for practitioners and academics in the new area of MaaS.

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