Personalisation in Mobility-as-a-Service: Where We Are and How to Move Forward

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Abstract: Within urban mobility ecosystem, Mobility-as-a-Service (MaaS) has come up as a promising approach to promote sustainable modes of transport and increase the attractiveness of public and shared multimodal mobility. It aims to become a viable alternative to personal cars for door-to-door trips. The long-term objective of MaaS is to change the people's travel behaviour by nudging them to make sustainable choices. However, changing people's travel behaviour is not easy and MaaS has to provide personalised mobility services, catering to the needs of each individual user, in order to be considered as convenient as a personal car. In this paper, we look at the existing literature on personalisation in MaaS proposed by the research community as well as different private MaaS service providers. This brief literature review helps in better understanding the current trends on personalisation and highlights certain limitations in the way it is incorporated within existing MaaS solutions. Based on these limitations, we discuss certain challenges which need to be resolved in order to improve MaaS in the future. These challenges present interesting research directions towards the development of personalised sustainable urban mobility ecosystem.

1 INTRODUCTION

Over the past few years, European Commission has been encouraging the development of Sustainable Urban Mobility Plans (SUMP) (EU Urban Mobility Observatory, 2023) for European towns and cities to tackle the challenges of climate change and urban traffic congestion. SUMP address the complexity of urban transport, integrate passenger and freight demand, and promote sustainable modes of transport to improve the overall quality of life.

To concretize the guidelines put forth within SUMP (EU Urban Mobility Observatory, 2023), cities need to improve their public transport infrastructure, integrate new modes of transport (such as car and bike sharing, on demand transport, carpooling, etc.) and develop platforms to improve the accessibility of public and shared mobility options. It turns out that the concept of Mobility-as-a-Service (MaaS) (Hietanen, 2014) can help overcome the challenges in implementing SUMP and, for a city, both SUMP and MaaS can be integrated and developed hand in hand (Signor et al., 2019).

Over the past few years, MaaS has gained significant interest in the urban mobility and transportation sector (Hensher et al., 2020). In essence, it aims to bring together different mobility services, provided by a single or multiple Mobility Service Providers (MSPs), on a single platform, with the possibility of searching, booking, and paying for such multimodal services directly on the platform (Hietanen, 2014). Furthermore, it supports the vision of mobility-for-all and pushes for access-based mobility services as compared to ownership-based mobility models with the objective of reducing the use of personal cars (Hensher et al., 2020). The concept of MaaS places user needs and environmental conservation at the center, while aiming for a seamless integration of multimodal mobility services.

One of the long-term objectives of MaaS is to gradually change people's travel behaviour and persuade them to make sustainable transport choices. According to (Hensher et al., 2020), MaaS has the ability to influence people's travel behaviour, however, it cannot achieve this objective if people are not incentivized to choose shared multimodal transport over personal cars. The authors propose that in addition to deploying MaaS, cities should also reduce

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the attractiveness of personal cars by restricting their use in certain areas and imposing parking regulations.

However, instead of "punishing" people for choosing personal cars, certain behaviour change strategies (Durand et al., 2018) can be integrated within MaaS which encourage people to choose sustainable modes of transport. Such strategies could improve the overall attractiveness of shared multimodal transport as well as the acceptance rate of MaaS as a concept.

In this paper, we focus on one such strategy to support behaviour change, *personalisation*. We discuss the aspect of personalisation within existing MaaS research and MaaS platforms developed by private MaaS service providers. After briefly presenting the concept of MaaS in Section 2.1, we discuss the importance of personalisation in Section 2.2, and how it is integrated in existing MaaS solutions in Section 2.3. From this brief review of the state-of-the-art, we are able to find some limitations in personalisation in existing MaaS solutions. These limitations are discussed in Section 2.4. In Section 3, we present certain challenges in order to improve personalisation in MaaS. These challenges are related to data availability, data standardization and data sharing between different stakeholders, respecting user privacy while processing and storing the collected data, integration of dynamic user preferences, and proactive route recommendations. We also discuss solutions to overcome these challenges highlighting fascinating research directions. Finally, Section 4 concludes the paper.

2 MOBILITY-AS-A-SERVICE

2.1 Brief Overview

Inspired by the business model of telecommunication sector, Hietanen (Hietanen, 2014) proposed the concept of Mobility-as-a-Service (MaaS) as *Netflix of transportation* where users would subscribe in order to use different mobility services provided by a mobility operator who, in turn, would be responsible for integrating such services onto a single platform. On the platform, users would be presented with different combinations of transport modes as well as different payment options (like mobility bundles, monthly subscription plans, etc.) which the user could choose according to his/her preferences and requirements. The idea was to develop the transportation system *with, to and by the users* as an *interconnected ecosystem consisting of transport infrastructure, transportation services, transport information and payment services* (Hietanen, 2014).

As the concept of MaaS gained traction, more definitions were proposed. For example, (Burrows et al., 2016) defined MaaS as *the provision of transport as a flexible, personalised on-demand service that integrates all types of mobility opportunities and presents them to the user in a completely integrated manner to enable them to get from A to B as easily as possible*. Similarly, (Kamargianni et al., 2018) defined MaaS as *user-centric, intelligent mobility management and distribution system, in which an integrator brings together offerings of multiple mobility service providers, and provides end-users access to them through a digital interface, allowing them to seamlessly plan and pay for mobility*.

In order to facilitate the understanding of MaaS, (Sochor et al., 2018) reviewed multiple definitions and proposed a topology to compare existing MaaS platforms. According to this topology, MaaS could be perceived at four different levels (from level 1 to level 4), each improving the services integrated at lower levels, ranging from the integration of information such as route planner, price, and environmental cost of a route (level 1) and payment options (levels 2 and 3) to the integration of societal goals (level 4) defined within government policies to incentivize the use of MaaS at large scale. Similarly to the work of (Sochor et al., 2018), other topologies that characterize MaaS have also been proposed in the literature. For example, (Opiola, 2018) considers MaaS at six different levels, with higher levels going beyond mobility and integrating other digital services (like smart homes and IoT) within MaaS. Taking into account the cognitive effort required to undertake a multimodal route, (Lyons et al., 2019) proposed a topology having five levels of integration, with higher levels associated to the requirement of lower cognitive effort. It is argued that, in order for MaaS to compete with the convenience of personal cars, it should be as easy, convenient, and flexible for everyone.

Out of various definitions explored in (Sochor et al., 2018), more than half describe MaaS as a personalised service for planning, booking, paying and executing the trips. Furthermore, from the different topologies discussed above (Sochor et al., 2018; Opiola, 2018; Lyons et al., 2019), one can note that, at higher levels, MaaS integrates multiple modes of transport with various payment options, while proposing personalised mobility services catered to the needs of the user. The importance of personalisation within MaaS is evident not only from the existing literature, but users also want MaaS platforms which provide personalised support, as noted by (Polydoropoulou et al., 2020) through a user survey and a focus group based study.

2.2 Role of Personalisation in MaaS

In the field of information systems, personalisation is defined as *the automatic adjustment of information content, structure, and presentation tailored to an individual user* (Perugini and Ramakrishnan, 2003). It takes into account the user's preferences and past habits while presenting relevant information or content at the time it is required (Gao et al., 2010), ideally without any explicit demand from the user (Mulvenna et al., 2000). The aspect of personalisation plays a key role in nudging the user and supporting him to change his behaviour (Prost et al., 2013) as well as improves the user's trust in the system (Briggs et al., 2004).

In case of multimodal transportation, incorporating personalisation as a tool to persuade users in changing their travel behavior has been discussed in the literature (Anagnostopoulou et al., 2018; Hensher et al., 2020). Furthermore, (Andersson et al., 2018) reviewed different behaviour change support strategies and concluded that personalisation plays a significant role in improving user satisfaction. Better satisfaction motivates the user to keep using the service which, in turn, has positive long-term effect in changing user behaviour. More so, personalisation has been identified as a core characteristic for any MaaS service as it makes it more attractive and improves its rate of acceptance (Jittrapirom et al., 2017).

The availability of heterogeneous information about different modes of transport and possible payment options within MaaS increases the complexity of using the service and choosing the right combination. As noted in (Hartikainen et al., 2019), users face difficulties in finding the relevant information about, for example, the schedule of public transport and where to buy tickets. This is especially true for unfamiliar areas and is a reason for increased travel-related stress (Hartikainen et al., 2019). Personalisation of the service helps in reducing the complexity of multimodal travel by providing right combination of modes and payment options at the right time. The trial of MaaS platform NaviGoGo in Scotland (Smith, 2019) showed that personalisation makes traveling easier and increases user's self-confidence in traveling using multiple modes. Simplifying multimodal travel reduces the cognitive effort required to make different choices, making MaaS as easy as using the personal car (Lyons et al., 2019).

Along with improving user satisfaction and reducing travel-related stress, personalisation plays a significant role in making recommendations to users. Recommendations maybe be about possible routes, between origin and a destination, with different modes of transport available or about available payment options (e.g. mobility bundles, subscriptions, pay-as-you-go, etc.) according to user requirements (Arnaoutaki et al., 2021). To make appropriate recommendations, user preferences are incorporated in terms of static user profiles (Arnaoutaki et al., 2019) or computed using the past data (de Oliveira e Silva et al., 2022).

In the following, we discuss some of the existing research on personalisation within MaaS as well as the features of existing MaaS platforms. The listed features personalise the user experience, as noted by the MaaS operators behind said platforms. Here, we focus only on information personalisation and not on the personalisation of payment options. For more information about the latter, the reader is directed to (Arnaoutaki et al., 2021).

2.3 Personalisation in MaaS Research and Existing MaaS Platforms

Within the MaaS research community, some work has been done to provide personalised mobility services according to the user's requirements. For example, (Melis et al., 2018) developed a microservice architecture to propose personalised and accessible routes to the users. The motivation behind using a microservice architecture is to make the software scalable by distributing its modules as microservices (Dragoni et al., 2017). The authors demonstrated the applicability of this approach by considering the use cases of a blind user and a tourist, and discussed the services required to deploy a personalised route planner for both use cases. In the proposed approach, user preferences (such as audible traffic lights, tactile information boards, acoustic announcements, etc. for blind users and scenic routes through historical buildings for tourists) were fixed while setting up the user profile and were taken into account while calculating the route between an origin and a destination.

Within the (MaaS4EU, 2020) project, (Georgakis et al., 2020) proposed a personalised multimodal route recommender integrating the information about third-party services for bike and car sharing modes as well as parking facilities. The route recommender was based on the choice architecture design elements where the users were provided with default route choices between an origin and a destination which can be filtered according to the user preferences (such as user's preferred walking and biking distances). Additionally, (Anagnostopoulou et al., 2020) constructed the users' "persuadability profiles" based on their personality types and proposed to attach personalised messages to nudge users towards sustainable modes of transport. The persuadability profiles described the

Table 1: Features of some of the existing MaaS platforms which personalise the user experience. Indicated features are susceptible to evolve over time.

MaaS Platforms \ **Features**	**Multimodal route planner**	**User profile**	**Sync with user's calendar**	**Real-time traffic information**	**Store fav. routes and locations**	**Display CO2 emissions**	**Occupancy of bike stations and parking lots**
Whim	✓		✓				✓
UbiGo	✓			✓			✓
Moovit	✓	✓		✓	✓		✓
Moovizy	✓			✓	✓	✓	✓
NaviGoGo	✓	✓					
WienMobil	✓	✓				✓	
Optymod'Lyon	✓	✓		✓			✓
TransitApp	✓		✓	✓	✓	✓	
Tuup/Kyyti MaaS Platform	✓		✓	✓		✓	
MobiPalma	✓			✓			✓
TripGo	✓		✓	✓		✓	
Ecomode	✓	✓				✓	✓
Compte Mobilité	✓			✓			✓

users' susceptibility to change their travel behaviour and were used as a tool for supporting behaviour change (Durand et al., 2018).

In addition to the ideas proposed by the research community, some existing MaaS platforms, developed by private MaaS operators, have incorporate certain features to personalise the user experience. These features are presented in Table 1. The list of platforms in Table 1 is not exhaustive but it gives a general idea of the level of personalisation in existing MaaS platforms. It is noteworthy that we only consider the features available on smartphone versions of the platforms, those available on the web versions are not considered.

All MaaS platforms have an integrated journey planner with which users can search for a trip using a combination of multiple modes available. Most of the platforms consider public transport, bike and car sharing, ride-hailing services etc. but some platforms like Moovit and Ecomode also integrate carpooling as a possible mode of transport. At the time of installation, the users are asked to register using their personal information such as age, email, phone number etc. (which is common for most platforms), but some platforms such as WienMobil, NaviGoGo, Optymod'Lyon and Ecomode ask for extra information, such as if the user owns a bicycle, a car etc. and how far is the user willing to walk in order to take a public or shared mode of transport. This information is used to create the user's profile which helps in filtering the route propositions presented to the user.

It is also possible for users to synchronise their personal calendars with MaaS platforms in order to receive automatic alerts about their trips which respect their daily constraints. Moreover, the option for storing preferred routes and locations eliminates the hassle to search for regular routes before every trip. Platforms like WienMobile and TransitApp display the carbon footprint with each route and incentivize users to choose sustainable options. In order to alert the user about traffic jams and delays in public transport, platforms such as TripGo, Optymod'Lyon, MobiPalma, and TransitApp take into account the real-time traffic information. In addition, TransitApp updates the bus schedules automatically when they are changed, for example, on weekends or during rush hour traffic.

Complementary to the ones presented in Table 1, platforms such as MobiPalma, Moovit and Moovizy integrate additional features to promote inclusive mobility as their services are available for people travelling with wheelchairs or those with visual impairments.

2.4 Limitations in Personalisation in Existing MaaS Solutions

Although the existing work, both from the research community and from private MaaS operators, is promising, there still exist some limitations which need to be resolved in order to improve the aspect of personalisation of MaaS. For example, user preferences and requirements need to be better taken into account and user feedback should be automatically integrated to enhance the service provided (according to the definition of the term *personalisation* presented in

Section 2.2). More importantly, user privacy should not be taken lightly. Users should be consented every time before processing their personal data (if done on third-party servers) or it should be stored and processed locally on their smartphones.

In the following, we briefly discuss these user-centric limitations of existing MaaS solutions:

- **User Preferences:** Existing platforms are able to filter the routes according to user preferences (such as shorter walking distance, less carbon footprint, less travel time etc.). However, user preferences, once integrated, are kept static. To the best of our knowledge, there does not exist a platform which automatically updates the user preferences over time. Furthermore, as discussed above, (Melis et al., 2018) take into account the static preferences of a blind user. However, the user is obligated to declare a personal health condition in order to use the personalised service. This might have an impact on the acceptability of platforms which are based on such methodologies.
- **User Feedback:** Most of the existing MaaS platforms demand explicit feedback from the users about their experience with the platform. However, feedback about the quality of the routes proposed and whether they conform to the user's requirements and context of travel is not considered. It has been shown that integrating user feedback makes the system more user-friendly (Belhajjame et al., 2011; Klinkmüller and Weber, 2021), however, current MaaS platforms are still limited in this aspect.
- **User Privacy:** One of the main issue with existing MaaS platforms is related to user privacy. Privacy policies of platforms such as Whim, TransitApp and Moovit are publicly available to enlighten the user about storage and potential use of her data. However, these policies are not easy to understand and sometimes provide conflicting information (Cottrill, 2020). More importantly, these policies are limited to the responsibilities of MaaS service providers, who store the user data on third-party servers, but do not extend to the companies maintaining these servers who are actually responsible for securing the data (Cottrill, 2020). Hence, the actual impact of existing MaaS privacy policies is fairly limited.

In addition to the above mentioned user-centric limitations, features enabling the personalisation in existing MaaS platforms need further improvements as well. For example, if a user prefers to use her bicycle or personal car in combination with public or shared modes of transport, she should be provided with this option. Existing multimodal route planners need to be improved to make "true" multimodality a feasible option.

Some existing MaaS platforms such as Ecomode and Moovit propose carpooling as a mode of transport. Moovit takes into account the needs of users acting as passengers and users acting as drivers separately. However, a user who uses carpooling both as driver and passenger is left out. Putting in place an efficient carpooling system is a challenge in itself (partly due to the complexity of ride-matching algorithms (Zafar et al., 2022)), but integrating carpooling with other modes of transport while taking into account varying preferences of passengers and drivers as well as the contextual information (such as if the passenger has luggage with him and if the driver's car has enough space to safely store it during the trip) further increases the complexity. There is a need to look for technical solutions in the form of efficient optimisation algorithms which would integrate carpooling as an attractive choice in the multimodal mobility space. Having discussed some user-centric and feature-centric limitations in personalisation in existing MaaS solution, in the next section, we discuss how these limitations can be resolved to make MaaS a personalised, secure, flexible and trustworthy choice for daily use.

3 IMPROVING PERSONALISATION IN MaaS

As discussed before, personalisation refers to presenting the tailored content to the user, according to her preferences, without explicit demand. Within MaaS, where mobility services are provided by different service providers, public and shared transport infrastructure is highly dynamic, and user preferences vary over time, personalising the information in real-time does not happen without challenges. In this section, we discuss some of these challenges and possible solutions to overcome them.

3.1 Integration of Dynamic User Preferences

Existing MaaS solutions take as input the user data (such as age, gender, preferred walking distance, does the user own a bicycle etc.) at the time of registration to set up user profile which is used to filter out incompatible routes. Some of these data (like preferred walking distance) define individual user preferences whereas other data (such as age, gender etc.) define preferences for a category of users. The user categorisation can help in understanding preferences at a higher level, however, in order to improve the large-scale acceptability of MaaS, individual user requirements and preferences need to be better incorporated into the system (Durand et al., 2018). In addition, user preferences are susceptible to change over time and they need to be updated in order to recommend optimal routes and/or payment options to each user.

One way to take into account individual user preferences is for the MaaS platform to observe the user in his daily routine and collect data about his trips using sensors (such as GPS and accelerometer) embedded in his smartphone. These data can be processed to extract the user's regular movement behaviour and automatically learn his preferences (such as his preferred departure time, preferred mode of transport, number of times he changes the mode of transport etc.).

There exist numerous approaches to process GPS and accelerometer data collected from the smartphones (Zheng, 2015; Hemminki et al., 2013; Zhang et al., 2023). Within the context of MaaS, the user's movement data could be processed in real-time in an online fashion by considering the incoming data as a stream (Gaber, 2012). Although stream data mining has been applied to numerous use cases, there exist certain challenges, such as handling delayed information, two-phased (offline and online) data processing, analysing complex data, etc. which need to be resolved in order to apply data stream mining to real-world applications (Krempl et al., 2014). Some of these challenges can be overcome using adaptive multi-agent system based methodologies, as discussed in (Grachev et al., 2020).

Once the GPS and accelerometer data is processed to compute the user's regular movement behaviour, his travel preferences can be extracted from this information. The Recommendation Systems research community has made huge contributions in modeling and updating user preferences while incorporating user feedback (de Gemmis et al., 2009). For example, collaborative-filtering based techniques consider user ratings given to various items by different users and tries to group users with similar interests so as to recommend similar items to them. Content-based recommender systems look at the content of the items being recommended and the attributes describing an item, and check if they match with user interests. It has been observed that incremental preference learning, where the preferences are updated in real-time is better than batch processing (Gallacher et al., 2013) for highly dynamic use cases (such as MaaS). Hence, such methods need to be incorporated within MaaS to learn user preferences in real-time and personalise the service provided.

3.2 Proactive Route Recommendations

Once the user preferences have been extracted from the user's travel data, they can be employed to recommend optimal routes to the user. Personalised MaaS should recommend such routes proactively, without any explicit demand from the user (as discussed in Section 2.2). From the user's regular movement behaviour, it can be anticipated that he/she needs to take a trip, between an origin and a destination, at a given time. Then, various possible routes between origin and destination can be ranked according to the user's preferences.

Recommender systems use ranking models to either calculate the rank (score) of a particular item (Score-based ranking) or use supervised machine learning where the score function is learned using some labeled training data (Learn-to-Rank approach) (Zehlike et al., 2022). Although these methods provide accurate recommendations, they might lead to "overly accurate" recommendations over time (McNee et al., 2006). The problem is that, generally, the recommender systems are developed to be accurate and over long-term they tend to recommend similar items which the user has used in the past.

This approach is problematic, especially for MaaS, since the objective of MaaS is to promote sustainable modes of transport and gently "nudge" the user to change her behaviour. If the route recommender system integrated within MaaS keeps making recommendations similar to the user's actual and past behaviour (which might not be sustainable enough), it would not be useful. Hence, from time-to-time MaaS route recommendation system needs to make unexpected and novel but relevant recommendations to promote sustainable options. This kind of recommendation is referred to as serendipitous recommendation (Ziarani and Ravanmehr, 2021). The challenge in implementing such serendipitous route recommendation system is the potential trade-off between what the user needs at a given moment depending on her past behaviour and preferences, and what and how often novel recommendations can be made to change her behaviour. This presents an interesting research opportunity for the MaaS community.

3.3 Privacy-Aware Data Storage and Processing

While learning user's regular movement behaviour, extracting his/her preferences and recommending optimal routes, his/her privacy should not be put aside. With this privacy-centric vision for MaaS, the question of data storage and processing presents a huge challenge. One solution is to store (with user's consent) and process the data on third-party servers. However, this does not fully respect the criteria of user privacy and also suffers from latency issues. A better approach for large data storage and processing is based on Mobile Edge Computing (MEC) (Mach and Becvar, 2017). MEC, a standard edge computing architecture, is different from traditional cloud computing since, with MEC, the data is processed in close proximity (in terms of mobile network topology) to the device which collects the said data. The idea is to exploit the capabilities of nearby (to a source device) mobile IoT-enabled devices to collectively process the data and send it back to the source device. This leads to improved latency and faster overall processing but there still exist certain privacy concerns (Ranaweera et al., 2021).

For MaaS applications, MEC provides an interesting alternative to store and process huge amounts of data (Xie et al., 2022). However, MEC is a relatively recent concept and comes with its own challenges such as optimised resource allocation, transparency, etc. (Ahmed and Rehmani, 2017). Overcoming these challenges present the objectives of recently launched EU funded (EMERALDS, 2023) project.

Recently, Federated Learning (FL) based methods have also been proposed to resolve the problem of user data privacy in MaaS (Chu and Guo, 2023). FL is a type of machine learning approach which is specifically designed to preserve data as well as model privacy (Zhang et al., 2021). In FL, the machine learning model is trained locally on the device which collects the data. In this manner, the data and the model are kept private and only the results are shared with other devices through a central server (in case of centralised FL) or directly over the network (distributed FL). Although interesting, FL based approaches are not without problems (Lyu et al., 2020) which require further investigations, especially in case of MaaS.

3.4 Data Availability, Standardization and Sharing

Finally, one of the major challenges in personalising mobility services is the lack of available real-time data (Maas, 2022). The data collected by different mobility service providers is not made available since most of these service providers are private entities and start-ups which have their financial needs in mind, and sharing their data with their competitors does not help their business. As mentioned in the report published by the House of Commons Transport Committee of the U.K. Parliament (House of Commons Transport Committee, 2018), it is the responsibility of the public authorities to get private businesses onboard and incentivize them to share their data with each other in order to develop an intelligent mobility ecosystem.

In order to share the data collected by different partners and promote interoperability, data standards need to be set up and common application programming interfaces (APIs) need to be developed to process the collected data (Polydoropoulou et al., 2020). Such APIs should provide access to real-time data about the state of road traffic, occupancy and location of all public and shared modes of transport available, users' location and travel-related data etc. to all the involved stakeholders in a secured manner. At this stage, the responsibilities of all public and private stakeholders about data sharing and data ownership should also be specified. The availability, standardization and sharing of real-time data between different service providers will help in improving the feature-centric limitations discussed above.

Furthermore, it is also possible that the available mobility services evolve over time with the addition of new forms of mobility proposed by new mobility partners. For their easy integration within existing infrastructure, micro-service architecture for data storage, processing and sharing could be a viable option (Dragoni et al., 2017; Maas, 2022).

4 CONCLUSION

Mobility-as-a-Service (MaaS) has grown into a promising solution integrating multimodal transport services, including public and shared modes, onto a single platform with the possibility of searching, booking and paying for using such mobility services. It aims to promote sustainable mobility, change people's travel behaviour over time, and reduce their dependence on personal cars. To become as convenient as personal cars, MaaS needs to propose personalised mobility services tailored to the needs of each individual user.

In this paper, we presented a brief literature review on the aspect of personalisation in existing MaaS research and MaaS platforms. Exploring various definitions of MaaS, we found that most of them describe it as a personalised service. This review then goes on to highlight current trends on personalisation within MaaS and lists some existing limitations related to integrating user preferences, user feedback and user privacy. Overcoming these limitations in the context of MaaS comes with certain challenges. The paper presents technical solutions which need to be studied by the research community and integrated within MaaS platforms. For example, instead of only relying on static user preferences to filter routes, MaaS platforms should also include their dynamic aspect. User preferences should be learnt and updated over time as the user continues to interact with the platform so as to make appropriate recommendations whenever required. Trade-off between recommendations according to user behaviour and sustainable mode choices needs to be further studied so as to nudge the user towards environment friendly mobility options. Instead of storing and processing user data on third-party servers, system architecture inspired from Mobile Edge Computing or data processing algorithms based on Federated Learning should be integrated within MaaS to store and process user data while preserving user privacy. The proposed solutions present exciting future research directions for improving personalisation within MaaS.

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