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Development path of MaaS platforms in China

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Abstract: As urbanization progresses, a novel urban transportation paradigm known as Mobility as a Service (MaaS) has emerged, addressing the principles of environmentally friendly travel and sustainable transport development. This paper presents a comprehensive overview of the research advancements related to the burgeoning transport concept of MaaS within the urban transportation sector. Utilizing a Reference review methodology, the authors articulate various perspectives on the evolution of MaaS and conduct a comparative analysis of demonstration applications based on the MaaS framework across different regions in China. Furthermore, the paper delves into the current state of MaaS in China, examining the challenges it encounters, while considering existing domestic MaaS platforms and the specific developments of MaaS in Guangzhou. Building upon this analysis, the authors propose strategies and approaches for the advancement of MaaS platforms in China. This study serves as a significant reference and guide for the promotion and implementation of MaaS within the Chinese context.

Keywords: intelligent transport; urban transport; travel as a service; shared transport; door-to-door service; MaaS platform

1 Introduction

With the progress of social development and the continuous improvement of people's living standards, residents' demand for high-quality travel has been continuously released. In recent years, the rapid development of rail transport has become the main status of urban transport services, and by the end of 2021, the annual urban passenger traffic will reach 99.384 billion, an increase of 14.0% year on year (MOT, 2021). China's urban public transport passenger traffic is 28 billion lower than in 2019, partly due to the impact of epidemics and partly due to the adoption of new transport services to meet daily travel needs. With the development of technologies such as IoT, big data and ITS, new responsive and on-demand shared transport modes have emerged to meet users' door-to-door travel needs, such as online taxis, carpooling and shared bikes. New transport service concepts are needed, as users travelling in multiple modes need to log in to multiple platforms, make multiple operations and separate multiple payments to complete a full door-to-door trip chain. However, increasing urbanisation and the varying coverage of different modes of transport have meant that a single mode of transport can no longer meet the demand for a full door-to-door journey, so a new and effective solution is needed.

In response to user demand for full-chain, door-to-door travel, the concept of Mobility and Services (MaaS) was first proposed at the 2014 EU ITS Conference in Helsinki, Finland. The concept aims to provide a user-centric, integrated digital platform for personalised, full-chain mobility services, including all modes of transport, booking, e-ticketing and payment for journeys from origin to destination planning. In 2016, the EU ITS Association led the establishment of the world's first regional MaaS Alliance, which laid the foundation for the development of global MaaS theories, methodologies, technologies and applications[1-3]. After rapid interpretation and development in recent years, it is considered an important research direction for the future transformation of urban transport worldwide.

In July 2019, the "Outline of the Digital Transportation Development Plan" clearly stated that "to build a digital

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mobility assistant, provide door-to-door customised services for passengers, and advocate the concept of Mobility as a Service (MOT, 2019)". In September 2019, the "Outline for the Construction of a Transportation Power" clearly stated that "vigorously develop shared transportation, build a service system based on mobile intelligent terminal technology, and realise mobility as a service (MOT, 2019)". Accelerating the development of MaaS has become an important task for building China's transportation power. According to the global experience of MaaS demonstration application, China has also started to demonstrate the application of MaaS platform pilots. For example, Beijing, Shenzhen, Guangzhou, Shanghai and other places have explored MaaS and initially realised the integration of travel information, travel planning, ticketing services and other functions. However, due to the different conditions at home and abroad, there is a lack of a new MaaS path suitable for domestic conditions.

Under the background of the National Transportation Power Strategy, in order to better carry out the implementation and upgrading of MaaS, it is necessary to analyse the implementation of MaaS pilots in various regions of China, and to give a MaaS development route suitable for China's national conditions according to the MaaS pilots in each region. This study explores MaaS models from the perspective of cities, rather than studying MaaS models suitable for various characteristics of a country from the national level.

After a brief introduction, section 2 introduces the concepts related to MaaS services. This section includes the definition of MaaS-related terms by introducing the definition of MaaS, the ecological structure and business model, the level of development of the platform and its own understanding. Section 3 goes through the analysis of domestic MaaS pilot projects, discusses the obstacles encountered in the development of the platform through the practical experience of Guangzhou MaaS, and finally gives a development path applicable to the domestic platform. Section 4 is the concluding section, which discusses the experience of the development of the platform and how it will develop in the future.

2 Reference review

2.1 The paradigm of MaaS

The definition of MaaS has evolved and is still in a state of flux. The first definition of MaaS, proposed by Hietanen[4], is that it is a "mobile distribution model in which a customer's primary transport needs are met through an interface and delivered by a service provider". The MaaS Alliance[5] broadly defines MaaS as the integration of various forms of transport services into a single travel service that can be accessed on demand. From a user-centric perspective, it is best described as "a digital platform with integrated services, including travel planning, booking, e-ticketing and payment for all modes of transport from origin to destination"[6], and can be broadly understood to include all modes of transport (including walking) other than the private car. According to Kamargianni[7], "Mobility-as-a-Service is a user-centric, intelligent travel management and distribution system in which integrators bring together the offerings of multiple mobility service providers and provide access to end-users through digital interfaces, allowing them to plan and pay seamlessly". Ho et al.[8] consider MaaS as an integrated system that integrates traditional services (e.g. public transport), other on-demand mobility services and shared services (e.g. carpooling, bike-sharing, car-sharing) and provides a single online interface for payment, trip planning and other traveller information. Summarising the definitional studies of various scholars, this author believes that MaaS must cover the following characteristics:

(1) Consolidated transport offer: Effective integration of traditional services and other on-demand shared mobility services such as taxi, ride-hailing, car rental, ride, bike and car sharing, and other micro-mobility services such as e-scooters and even walking‖.

(2) An all-in-one digital platform: Bringing together information from all participating entities in a digital service platform. Digital integration of individual functions.

(3) Intermodal journey planning: The digital MaaS platform can carry out multimodal process planning, and a complete planning can provide functions such as booking, ticketing and payment; provide real-time information needed to plan and execute the journey; solve problems that arise along the way.

(4) Bundles of services: Users can purchase bundled services according to the number of trips they make to reduce travel consumption. Personalised bundles of services can also be provided.

(5) Payment options: The user can choose their own payment method and their travel needs can be met on a pay-as-you-go basis or in the form of a regular subscription to a mobile service bundle.

(6) Inclusion of additional services: Some other additional services can be provided, such as parking services, petrol station information, points collection and other services.

(7) Multi-stakeholder collaboration: A complete MaaS platform requires the cooperation of several parties. The integrated digital platform can be used to integrate and access more detailed travel data from users across the chain, arrange advertising and other services, and also provide decision-making for the government, creating a win-win situation for all parties.

2.2 The structure and business model of the MaaS ecosystem

2.2.1 The ecological structure of the MaaS

To bring MaaS to life and ultimately deliver a seamless travel experience to end users, a number of stakeholders need to work together. These stakeholders define a MaaS ecosystem (Figure 1), while the way they work together contributes to the development of different business models for MaaS.

• MaaS provider: Responsible for integrating all dynamic and static resources, working closely with various entities, realising the functions of each module of MaaS, and providing travel services to users.

• Transport service providers: Transport service providers are composed of public transportation companies and private service companies, of which public transportation companies mainly cover public transportation and customised buses and ride-hailing minibuses for on-demand travel, and private service companies mainly engage in on-demand and shared service transportation modes such as ride-hailing, carpooling, and shared bicycles.

• Enabling technology and service providers: Various technology and service providers mainly play a supporting role in the implementation of various functions of the platform, such as data interface, ticketing system, payment integration, multimodal operation, and other functions.

• National and local authorities: They mainly play a leading role in the MaaS system, which is mainly responsible for policy formulation, data openness, financial support, and market supervision and management.

• Customers: Users need to provide personal information and pay fees, and enjoy the integrated travel services provided by the MaaS platform.

• Other value-added institutions: These institutions can support the development of MaaS platforms, for example, insurance companies are conducive to protecting the rights and interests of users, and at the same time can increase the willingness to use MaaS and purchase packages. Schools and research institutions can effectively optimise the development of MaaS platforms by studying the data of MaaS platforms.

2.2.2 Business models of MaaS

MaaS systems are available in three development directions: market-driven development (fully private), public-controlled development (fully public), and mixed public-private development (hybrid), each with its own advantages and disadvantages, as shown in Table 1.

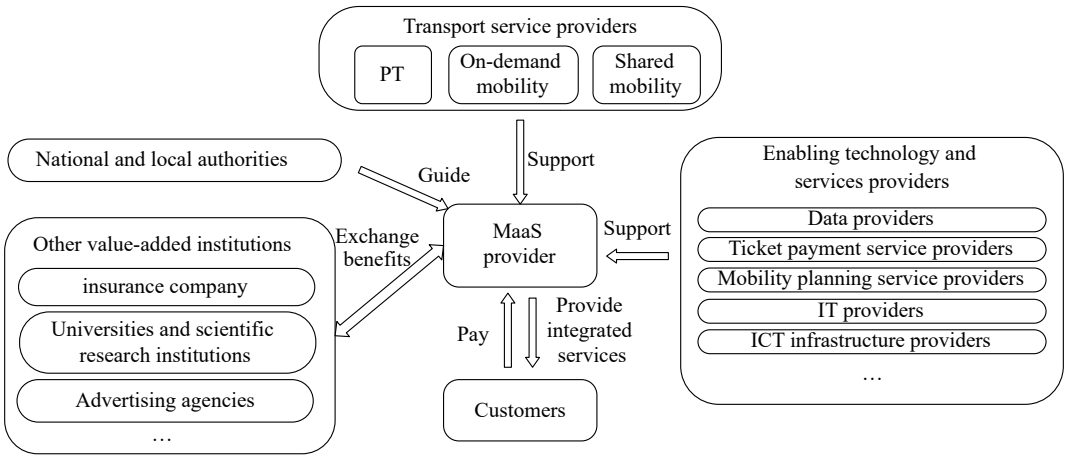

Fig. 1 The ecological structure of MaaS

Table 1 Characteristics of business models

Business models of MaaS	Advantages	Disadvantages
market-driven development (fully private),	Rapid innovation: able to innovate and adapt quickly to market demands. Fierce competition: different MaaS providers will compete to introduce better products and services, which will promote the improvement of service quality and competitive price reductions. Diversified funding sources: funding can be obtained through investment investors and business cooperation, not only relying on government grants but also leveraging private capital.	Inequality issues: MaaS services may appear to be unevenly distributed in cities. Business motivations: often focused on profitability, easily neglecting social welfare and sustainability issues. Lack of overall planning: there is often a focus on meeting market demand and profitability, and a lack of overall urban planning considerations, which may be inconsistent with urban transport policies.
public-controlled development (fully public)	Equitable and accessible: can ensure a fair distribution of services in the city. Socially oriented: can focus more on social welfare and sustainability objectives rather than just profitability. Urban master planning: can be better integrated with urban master planning to promote the integrated development of urban transport.	Lagging innovation: Publicly controlled organisations may not be as flexible as private companies and may be slower to innovate and adapt quickly to market changes and technological advances. Limited funding sources: often dependent on government grants, funding sources are limited to meet major investment and expansion needs. Lack of competition: leads to a decline in service quality and levels of innovation, and does not provide incentives for MaaS providers to offer better services.
mixed public-private development (hybrid)	Leveraging resources: Optimal allocation of resources can be achieved by combining the innovative capacity of the private sector with the planning capacity of the public sector. Balancing multiple objectives: The hybrid model can balance market dynamics and public interest, focusing on commercial profitability while meeting the overall transport planning and social needs of the city. Flexibility and efficiency: The hybrid model allows for a public-private partnership mechanism that can be more flexible and efficient in responding to market and policy changes.	Institutional and governance complexity: A hybrid PPP-MaaS system involving different types of partners can lead to increased complexity at the management and decision-making levels, and effective cooperation mechanisms are needed to address these issues. Conflicts of interest: There may be conflicts of interest between different partners, which need to be properly addressed in PPPs. Different standards: The private and public sectors often have different management standards and objectives, which may require more effort to achieve consensus and cooperation.

Taken together, each path has its own unique advantages and challenges. The public-private partnership (PPP) model is often seen as a worthwhile direction to try, leveraging the strengths of all parties to achieve a more comprehensive and sustainable mobility solution. For example, public transport companies in the western region of Sweden have partnered with the private sector to achieve a higher level of service; the Nordic experience shows that governments have a positive role in guiding the development and implementation of MaaS systems by setting the course for development. Too much regulation by public authorities can hinder the private sector's ability to participate and innovate, resulting in unattractive MaaS systems; too little regulation can result in MaaS systems that are not in the public interest. Finding the regulatory "sweet spot" with appropriate rules and incentives is therefore key to promoting the sustainable development of MaaS systems.

2.3 Development level of MaaS system

Various experts and scholars have defined the stage of development of the MaaS system. Although the expressions are different, the ultimate goal is to realise the multi-mode integration of urban services and transportation services. Literature[9] divides the development of MaaS into five stages: stage 1 is the stage of no information integration, a single and independent service mode; stage 2 is the integration of travel information, multiple travel modes can be selected, and the possible time, cost estimation; 3-stage booking and payment integration, booking and payment for services required for a single trip, not only including transportation travel; 4-stage service supply integration, collecting users' daily travel information online, and providing users with "travel information" offline "package" service; 5-stage integration of social goals. Reference [10] classifies the MaaS system according to the scale of integrated function, and

divides it into basic integration stage, high integration stage, and customised mobile service package integration stage. Reference [11] believes that in MaaS1.0, sharing is mainly used to improve efficiency and alleviate the contradiction between people, vehicles and roads to some extent; in MaaS2.0, sharing + intelligence will comprehensively improve efficiency and completely eliminate the contradiction between the three. Reference [12] divides the MaaS system into 6 levels according to the degree of integration, among which Level 0 is the stage of no integration, and various travel service software work independently; Level 1 is the stage of basic integration, which basically integrates urban public transport services, but platform payment cannot be realised; Level 2 is a limited integration stage, and platform payment is realised on the basis of Level 1; Level 3 is a partial integration stage, and functions such as planning, reservation and payment can be completed under a single platform; Level 4 is a special case in the fully integrated stage, the operational integration of various transport modes can only be achieved under specific service conditions and designated areas; Level 5 is fully integrated under all conditions. Reference [13] divides MaaS into information integration (multimodal travel planner), booking and payment integration (multimodal transport for one-way tickets), service delivery integration (multimodal mobile services based on bundled subscriptions), social objectives integration (influencing user behaviour through transport planning and incentives enabled by dynamic data sharing between MaaS operators) level 4.

3 Domestic MaaS pilot construction Demonstration

3.1 MaaS pilot in China

In recent years, China has gradually attached importance to MaaS, and various regions have carried out the development of MaaS platforms.The promotion of MaaS platforms has shown a trend of gradual development, and generally large cities have started to pilot and promote MaaS platforms earlier. These large cities tend to have a large scale and high pressure of transport demand. With the acceleration of urbanisation and the growing demand for transport and travel, the promotion of MaaS platforms can better meet the diverse travel needs of citizens.

The Beijing MaaS platform was launched in Beijing in 2019, and is the first integrated MaaS platform in China. Based on the AutoNavi Map, the platform integrates all categories of transportation services, such as buses, subways, suburban railways, walking, cycling, ride-hailing, aviation, railways, long-distance buses and self-driving, and can provide citizens with the whole process of pre-departure intelligent decision-making, full process guidance during travel, and post-departure green incentives, one-stop “door-to-door” travel intelligent guidance and intercity travel planning services. The platform also provides bus users with a variety of travel planning suggestions, such as “subway priority, less walking, fewer transfers, and short time”, and citizens can switch between different preferences by swiping horizontally.

In August 2019, Shenzhen Bus Group conducted a MaaS practical trial in Shenzhen Science and Technology Eco-Park to carry out an intelligent travel service demonstration pilot, and officially launched the MaaS intelligent travel service “SOGO Travel” applet. The pilot will run two MaaS bus lines every day in the morning and evening rush hours to transport passengers to and from the park to the high-tech park and Keyuan metro station, to achieve “metro + bus” seamless integration, improve the level of public transport services and explore the attractiveness of improving public transport travel. Passengers can make reservations in advance through the “SOGO Travel” applet, which not only allows one person per bus, but also allows passengers to make stops according to their needs, providing on-demand customised bus services for commuters in the park.

The Guangzhou MaaS platform is Yang Cheng Tong which was launched in Guangzhou in 2018. It is operated by Guangzhou Yang Cheng Tong Co, Ltd. which was jointly established by Guangzhou Public Transport Group Co, Ltd. and Guangzhou Metro Group Co, Ltd. Yang Cheng Tong provides citizens with 9 travel modes: bus, subway, taxi, car rental, passenger ferry, taxi, passenger transport, bicycle and car information collection; for bus, subway, bicycle and taxi, the platform also provides route planning and payment functions for these four travel modes. For rail transport, Yang Cheng Tong mainly realizes the intermodal planning, information collection and payment service collection of the subway, the platform provides citizens with the interline planning of the subway and bus, walking, in addition, the platform mainly collects the static information of the subway, such as the line network map of all subways, but does

not collect real-time information, such as the subway arrival time, and passengers can take the subway through the QR code on the sweeping Yang Cheng Tong, and the subway payment code can also be used for bus payment. Yang Cheng Tong mainly integrates inner-city travel modes, and has not yet integrated services and information of intercity travel modes such as intercity rail (such as high-speed rail), but it is already in the planning stage. Yangcheng Pass has a huge user base, according to China One Card Network, the number of QR code registrations in Yangcheng Pass has exceeded 20 million by 2019. Currently, the Guangzhou municipal government is focusing on optimising and integrating data from different travel modes and introducing better travel services so that the platform can better serve the travel needs of Guangzhou citizens. Launched in October 2022 under the leadership of the Shanghai Municipal Government and Shanghai State-owned Enterprises, Suishen Walk will provide citizens with four modes of travel: bus, subway, taxi and driving interline planning, payment and reservation services, and launch a game-based green point game to encourage citizens to travel green. For rail transport, the platform mainly provides intermodal planning and payment services for the subway, the platform can plan multi-mode travel routes for citizens to combine subway with bus and walking modes; in addition, citizens can take the subway through a QR code, and the subway payment and bus payment, health code to achieve "three codes in one", residents can use the same code to take the bus subway, without scanning the code separately or presenting additional health codes. However, the platform is currently working on integrating more intercity travel services, such as railways, and expanding the scope of services to the Yangtze River Delta region.

Through the analysis of up to 90 MaaS Reference by Daniela et al.[14], it can be summarised that a perfect MaaS platform must include three main characteristics: APP-related functions, mainly covering six functions: real-time information, travel planning, payment integration, subscription, ticketing, data access; travel service provision, mainly covering various public transport services, on-demand travel services and shared service modes; travel packages, transport packages are bundles of various transport modes, and now the main ways are weekly/monthly/quarterly packages, customised packages and pay-as-you-go. The development of domestic MaaS pilots was collated using this approach, as shown in Table 2.

Table 2 The development of domestic MaaS pilots

MaaS system and date	Service region	App-related features	Mobility service offer	Offer mobility packages
Beijing MaaS, 2019	Beijing	Route planning, Partial Information integration, Payment Integration	Bus, Subway, Walking, Plane, Bike, Car, Parking, Bike sharing	pay-as-you-go
Guangzhou MaaS, 2020	Guangzhou	Route planning, Partial Information integration, Payment Integration	PT, Walking, Bike, Bike sharing, Car	pay-as-you-go, Weekly/monthly package(Bus/Subway/Sharing Bike)
SOGO Travel, 2019	Shenzhen	Route planning, Partial Information integration, Payment Integration	Bus, Subway, Car, Walking	pay-as-you-go
Shanghai MaaS, 2022	Shanghai	Route planning, Partial Information integration, Payment Integration	PT, Car, Walking, Parking	pay-as-you-go

From Table 2, we can see that most of the existing MaaS pilots have not yet been able to provide dynamic and real-time information, according to Reference [15-16] et al. Users are attracted by real information about passenger congestion, pollution levels, route amenities, vehicle conditions and urban safety. Currently, many apps in the country only integrate some public transport services and do not have many shared mobility services. However, an ideal MaaS should try to include as many mobility services as possible to cover most of the transport services (public transport and shared mobility services) offered in the city. Many studies[17-18] have shown that the more mobility services included, the more attractive the MaaS service will be. Apart from that, travel packages basically only offer pay-as-you-go.

In the process of promoting MaaS platforms, these large cities usually receive policy support and resource investment from the government. These cities have a rel-

atively well-developed transport infrastructure and public transport network, and the government's willingness and support to promote smart mobility and sustainable transport is high. In addition, these cities have strong strengths in technological innovation and digital development, which are conducive to integrating transport data and technological resources, promoting the construction and operation of MaaS platforms, and providing smarter and more efficient mobility services to meet the growing mobility needs of citizens.

3.2 Development of MaaS platform —Guangzhou MaaS

In the early stages of construction, the MaaS platform faced the development challenges of how to build, how to operate, how to serve and how to govern. To solve this problem, a new concept was proposed based on past experience: "always focusing on one network, one code, one ticket and one stop as the four ultimate goals of digital mobility" to carry out the organisation and construction.

Guangzhou is starting by opening up the city's transport modes and ticketing system, gradually integrating intercity transport modes, and then connecting railways and civil aviation to the travel platform. Based on existing travel service platforms such as "Yangcheng Tong Travel", "Ruyao Bus" and "Ruyao Taxi", Guangzhou has built a one-stop travel platform for public transport. This travel platform includes a number of sub-systems, such as an aggregated payment code system, an electronic ticket management system, a travel programme planning and subscription management system, a digital integration system for travel and lifestyle services, and a community management system for travel services.

(1) One Network: Promote the integration and interaction of digital scenarios between travel networks and life networks.

(2) One-Code Pass is similar to One-Ticket Pass: dynamic resource allocation is performed with travellers/users as the core, and payment forms such as boarding codes and electronic tickets are used as connectors.

(3) One-stop: It means integrating discrete modes of transport into an integrated travel platform and providing multi-mode transport combination, door-to-door, seamless, high quality travel services.

For the dimension of MaaS integration in Guangzhou, it needs to be divided into 5 stages, and currently Guangzhou MaaS is in stage 3, and is also working on building a one-stop digital travel service platform in Guangzhou.

(1) MaaS Stage 0 is to integrate and eliminate the redundancy of the various travel service platforms, unify the data standards and interfaces between the platforms, realise the digital transformation within the public transport companies, and facilitate the service integration work of the platforms.

(2) MaaS Phase 1 is the establishment of a preliminary MaaS platform based on the modules of each existing platform to realise the application of business scenarios such as public transport and metro. This phase focuses on services such as technical capabilities and operations and maintenance, and establishes the transport sector and payment system.

(3) MaaS Phase 2 is to further improve the technical standards of the MaaS platform, integrate the existing travel services of various platforms, online platforms and other infrastructure, establish unified account management, payment management, order management, etc., dock the travel business system of various enterprises, connect and link the travel service platforms of various enterprises, and complete the construction of service function applications. This stage also includes access to real-time bus information services and ticket information services to enhance the experience of bus travel services and provide users with personalised travel planning and guidance on local life services before and after travel. In this phase, Yangchengtong has explored public transport and public welfare bike-sharing, and launched corresponding monthly, weekly and sub-tickets, laying a solid foundation for future enterprise cooperation.

(4) MaaS Phase 3 is to collect user feedback and optimisation requirements during platform operation, and carry out platform iteration and improvement work. This phase aims to realise passenger transport services for all modes of transport in Guangzhou, establish standardised data interface management, and carry out the integration of multiple service industries. At this stage, the Guangzhou MaaS platform has basically realised the new service of "one-stop + one-ticket". At the same time, it started to try to add consumer services in tourism, catering, accommodation, entertainment, shopping and other related fields, and carried out simultaneous and deep integration to provide users with more comprehensive travel

services and one-stop consumer experience.

(5) MaaS Phase 4 is to expand the MaaS platform from city to city, extend the scope of one-stop travel services in Guangzhou to the Guangdong, Hong Kong and Macau Bay Area, and create a new mode of intermodal passenger transport services with the characteristics of the Guangdong, Hong Kong and Macau Bay Area, so as to optimise travellers' travel experience and promote the transformation and upgrading of the industry. This means that the MaaS platform will transcend city boundaries and integrate travel services from different cities, making inter-city travel more convenient and seamless.

3.3 Status and challenges of MaaS development

Some regions, cities and industrial enterprises are actively exploring platform construction and application, and there is a good atmosphere for development. However, given the complexity of the MaaS service system, MaaS is still in its infancy in China, and the various layers of MaaS construction are generally still facing the development challenges of how to build, operate, service and govern. However, building a recognised and unique MaaS platform to achieve these goals will take a long transition period due to the limitations of digital technology and other reasons.

A collation of MaaS pilots in each region shows that it is still in its infancy, with partial functionality being completed for implementation at each stage. There are many barriers to the building process, in three specific areas: Technical barriers, organisational barriers and environmental barriers.

3.3.1 Technical barriers

Data and Cyber Security, MaaS involves public and private providers and customers and contains a large amount of data, including personal information (e.g. payment details and travel logs), business data (e.g. costs, charges, service records, etc.) and other open data (including timetables and service locations). For users, there is the issue of privacy, i.e. personal and payment information may be accessed by illegal sources, leading to property and personal security issues. For businesses, the fear of intellectual property rights being infringed, which could lead to loss of business competition and loss of business.

Different payment systems, A well-established MaaS platform needs to be completed in a public-private partnership and therefore differs in the way payments are made. The different modes of transport will also lead to different forms of payment. The most important issue is the clearing of services between companies. It is crucial to achieve proper clearing and the integration of different payment systems is a complex project.

Multiple sources of disparate data, The multimodal nature of travel inevitably brings with it multiple sources of traffic data that are large and heterogeneous. How to use the existing traffic data for in-depth integration, analysis and mining to achieve accurate control of the demand side and supply side of real-time dynamic on-demand deployment. The use of multi-source traffic data can make more accurate decisions for the government and make a significant contribution to the subsequent layout of enterprises.

3.3.2 Organisational barriers

Lack of collaboration between stakeholders, MaaS aims to integrate the various transport services within the city and needs to take into account a wide range of competing interests, objectives and policies from the private and public sectors, users and the wider community. Good collaboration between the two sectors and across administrative boundaries can help address service constraints, including funding, staffing, technology and capacity requirements.

Boundaries of roles and responsibilities of participants in the emerging ecosystem, As the MaaS concept is a recent emergence, it needs to be constrained by relevant regulations, as the exact positioning of the roles played by each participant and the scope of their responsibilities are not well defined. The goal of integrating mobile services into a holistic platform seems unlikely to be achieved without financial incentives for participants, and without clearly defined roles and boundaries of responsibility, this may lead to a lack of motivation and a tendency to create monopolies.

3.3.3 Environmental barriers

As this MaaS concept is new and most people in the country are not aware of the differences between MaaS platforms and other platforms, barriers to communication may arise, making many companies reluctant to participate in collaborations. However, as platforms become more functional, and as the features commonly used by different groups of people (seniors, public transport

users, etc.) are different, consideration should be given to allowing users to personalise their experience (e.g. tailored trips based on personal preferences and tailored subscription bundles).

4 Analysis of the development path of domestic MaaS platform

In developing domestic MaaS platforms, they face challenges such as technical barriers, organisational barriers and environmental barriers. To achieve the comprehensive development of MaaS, the following strategies and platform development paths are described for each barrier.

4.1 MaaS development strategy

(1) Strengthen data and network security measures, establish a strict privacy protection mechanism, and adopt technical means such as data encryption, access control and identity authentication to ensure user data security. Promote interoperability among different payment systems and establish unified payment interface standards to achieve seamless payment. Adopt big data technology and artificial intelligence algorithms to integrate and analyse big traffic data from multiple sources, extract valuable information and support government and enterprise decision-making.

(2) Establish a cooperation mechanism among multiple stakeholders, including government departments, transport operators and travel service providers. Clarify the role and scope of responsibility of each participant, and establish an appropriate incentive mechanism to motivate participants. Strengthen the government's role in regulation and planning, and promote joint cooperation among all parties to form an overall synergy to solve service constraints and resource allocation problems.

(3) Carry out extensive publicity and education activities to increase public awareness and acceptance of the MaaS concept and platform. Promote personalised experiences and provide customised travel services to meet the diverse needs of different user groups. Formulate relevant regulations and policies to support and protect the development of MaaS platforms, encourage the development of MaaS pilot projects, and provide policy incentives for outstanding MaaS platforms.

4.2 MaaS platform development paths

By analysing the development history of MaaS platform in Guangzhou, the development path of domestic MaaS platform is analysed and studied for the existing MaaS development status, and it is divided into five stages, which is more in line with the current domestic MaaS development path.

(1) Starting Stage (Stage 0): such a situation makes it difficult for different subjects to merge, which may lead to problems such as monopoly operation, lack of comparison and reduced efficiency. Therefore, regions need to start with institutional changes and propose new institutional mechanisms for MaaS management that promote cooperation among operating companies.

(2) Basic integration stage (stage 1): The main goal of this stage is to integrate public transport by digitally transforming discrete platforms within public transport companies, identifying standard interfaces, sharing data, etc. to complete integration. The creation of a clearing system for payment integration is also a top priority.

(3) Multimodal integration stage (Stage 2): This stage involves researching the travel needs of people travelling by multimodal modes in order to maximise the benefits. The bundled travel services with the highest demand will be selected for win-win cooperation between companies, and benefit clearing will be completed to promote the development of travel packages.

(4) City-wide coverage stage (Stage 3): Complete the integration of various transport modes within the city, including on-demand travel and shared travel, real-time traffic information integration, and establish a unified data interface system. It also includes various extended services within the city, such as parking services and point exchange.

(5) Inter-regional integration stage (stage 4): This stage aims to complete the integration of inter-city transport modes, including rail and high-speed rail. A perfect ticketing system must be established due to the different forms of payment.

Overall, the development of MaaS platforms has seen a gradual progression from a discrete, non-shared situation to the integration of public transport, and then to the exploration of multimodal travel demand and the development of travel packages. This was followed by the integration of intra-urban transport modes and the integration of inter-urban transport modes. Progressing through these five stages will help solve the challenges of MaaS development and provide smarter and more convenient travel options to meet the diverse travel needs of the public.

5 Conclusion

With the diversification of travel services, resulting in redundant platforms and a sudden increase in the number of software, it is cumbersome for people to complete a full chain, door-to-door trip.The introduction of the MaaS concept has brought new hope for solving this problem. Various countries have started to implement various MaaS demonstration applications, gradually exploring development paths adapted to local conditions. By analysing the development process of MaaS through the literature, researchers have proposed new definitions and ecologies to provide a theoretical basis for the practice and development of MaaS. Meanwhile, the analysis of existing MaaS platforms at home and abroad, as well as the development of MaaS in Guangzhou, also provides lessons and references for exploring the development path of domestic MaaS. The development path of domestic MaaS platform starts from the initial stage and gradually develops to the cross-regional integration stage. At each stage, corresponding technical, organisational and environmental barriers are encountered, requiring the government, enterprises and various stakeholders to work together to promote the development of MaaS platforms. With the continuous accumulation of user usage data, the development path can be adjusted and optimised according to the actual situation in the future, so that the MaaS platform can be better adapted to the travel needs of the public and provide smarter and more convenient travel services.

Overall, the development path of domestic MaaS is a continuous evolutionary process that requires constant innovation and improvement to adapt to the diversified needs of travel services. Through the continuous accumulation of experience and data, we can provide more scientific and effective guidance for the development of MaaS, and promote the comprehensive improvement and expansion of intelligent travel services.

Declaration of competing interest

The authors have no competing interests to declare that are relevant to the content of this article.

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