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Mobility as a Service (MaaS) and Transportation Integration in Jabodetabek: A Thematic Analysis of Infrastructure, User, and Regulatory Perspectives Toward Sustainable Urban Mobility

Dody Suhermawan
PT Galena Perkas Logistik, Surabaya. East Java.

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Abstract

Rapid population growth and increasing mobility in Jakarta and the greater Jabodetabek region have intensified the need for an integrated, multimodal transportation system that supports urban efficiency and sustainability. This study examines the development and implementation of Mobility as a Service (MaaS) as a technology-driven framework that integrates transportation modes, digital platforms, and network management systems to improve passenger mobility. Using a qualitative approach with thematic analysis and data triangulation, data were collected through desk research, in-depth interviews, focus group discussions (FGDs) with academics, practitioners, operators, and government stakeholders, as well as field observation across the 2021–2023 period. The analysis focuses on three main dimensions: infrastructure integration (information technology systems, transportation modes, and regulation), actors and consumers (user types, travel behavior, and communication channels), and value proposition (service integration, modal connectivity, and coverage). The findings reveal that although physical, payment, and schedule integration efforts—such as JakLingko and integrated transit hubs—have progressed, significant challenges remain, including limited first-mile–last-mile connectivity, fragmented fleet management systems, inconsistent regulatory frameworks, and unresolved land and subsidy allocation issues. The study highlights the critical role of integrators and Public-Private Partnerships (PPP) in bridging these gaps, and demonstrates how the combination of MaaS, the Internet of Things (IoT), and Network Management Systems (NMS) can enhance socio-economic welfare, reduce congestion, and support sustainable urban transportation. These findings contribute to a more comprehensive understanding of MaaS implementation in a rapidly urbanizing metropolitan context and offer policy-relevant insights for transportation authorities and service integrators.

INTRODUCTION

Multimodal transportation services that are physically, temporally, schedule-wise, and cost-wise integrated are essential for the efficiency of urban transportation. In addition, security and safety factors also become considerations for the public when choosing a mode of transportation (White, 2016).

A sustainable transportation system is a system that provides access to the basic needs of a person or society in a safe manner and consistently with the health of ecosystems and human beings, while ensuring fairness for present and future generations of society (Sierpiński et al., 2023).

Increasing mobility in Jabodetabek has become a daily phenomenon and contributes to the economic growth of the region. Urban areas remain places to live and ways of life that provide income security. By 2045, Indonesia will become the country with the fourth highest population in the world, with nearly 70% of its population living in urban areas, and this continues to change due to increasing urbanization (Roberts et al., 2019).

According to a report by the Central Statistics Agency (BPS), the number of motor vehicles in DKI Jakarta has continued to increase over the past five years. The number of motor vehicles (cars, buses, trucks, and motorcycles) reached 26.37 million units in 2022, an increase of 4.39% from the previous year. The chart shows a consistent percentage growth of motor vehicles, ranging between 17% and 21% per year. In addition, the data shows that 17.3 million units, or 65.6% of the total motor vehicles in DKI Jakarta, are motorcycles.

According to the Coordinating Ministry for Economic Affairs (Kementerian Perekonomian, 2019), transportation has become an important part of urban life because more and more people need to carry out activities outside the home, particularly those related to earning a living, lifestyle, or entertainment. For this reason, transportation is very important and must be supported by a system that can meet the community's needs for comfortable transportation and make people confident in using it because they feel they have reliable transportation.

MaaS (Mobility as a Service) is a multimodal mobility framework that places the user as the main focus, in which this concept integrates a digital platform that provides travel information, booking, ticketing, and payment (Alyavina et al., 2020). In the implementation and operation of MaaS, it is more efficient to use a platform with a single user identity, an open back-end, and an integrated payment method. This concept can be applied in public transportation operations, using mobile devices as a platform for accessing information, purchasing tickets, and verifying tickets when boarding a mode of transportation.

By combining social traffic management systems, mobility management as a service, and network management systems, improved mobility can be achieved (Van Den Dries & Rodrigues, 2018). Where 80% of interactions with passengers relate to requests for information, travel, and validation, these can be carried out digitally and automatically through

platforms and applications. Most of the remaining operations, or twenty percent, are conducted through one-on-one communication, which is required to answer specific questions and requests such as pick-up points, special routes, parking areas, and mode options. Because all data and information are updated in real time, this scheme has added value. It can be used to handle various kinds of delays, disruptions, trip development options, and information about trips before and during travel.

In the transportation services market, the integration of data and payments from various modes of transportation will improve companies' business models and provide the best service for passengers. In addition, comprehensive education is needed regarding the user perspective, the legal structure, and the business model (Feneri et al., 2022). Integration with public transportation will increase the reach of passenger mobility and create transportation hubs, in addition to government subsidies for the majority of public transportation fares (United Nations et al., 2020).

Travel purpose and frequency are manifestations of individualization. This approach can influence how customers spend their time during a trip. When traveling, short-distance, repeat passengers strongly need an internet connection, while medium- and long-distance leisure travelers need luggage space.

The need for integration underlying this research shows that an in-depth analysis is needed to determine a method suited to the current characteristics of Jabodetabek. This is particularly important given the increasing number of mobility needs with different backgrounds and purposes.

Mobility as a Service, abbreviated as MaaS or translated as Mobility Service, is the integration of transportation in any form (train, bus, taxi) that supports all aspects, from route search to payment, integrated across transportation operators (Arias-Molinares & García-Palomares, 2020). This initiative is aimed at ensuring the smoothness and comfort of passenger travel as the main focus of transportation providers' services.

Basically, a Network Management System (NMS) is software designed to monitor, maintain, and optimize network performance. NMS can also monitor hardware and software components (Desmira, 2020).

One of the indicators that determines effective and efficient transportation services is as follows: safe, accessible, integrated, sufficient capacity, orderly, smooth, fast, easily reachable, punctual, comfortable, affordable fares, orderly, secure, pollution-free, low public burden, and high utility. In addition, there is the Single Seamless indicator, which includes a single operator, a single document, and a single ticket for passenger transport.

In general, the operation of the Internet of Things consists of main components, namely physical objects equipped with IT modules, devices connected to the internet, and cloud data centers, also known as cloud data centers, which function as storage. The working principle of the Internet of Things is that all physical objects connected to the internet will generate large amounts of data, which are then

stored as Big Data and subsequently analyzed for various purposes (Hawley, 2022).

There are many economic benefits provided by the transportation system: direct benefits (capacity and efficiency), indirect benefits (accessibility and economies of scale), and induced benefits (multiplier effects and opportunities). Transportation improvements typically increase the scale and scope of the economy (mostly for goods and providers). MaaS affects the economy, as well as transportation supply and demand (Rodrigue & Jean-Paul, 2020).

Sustainable transportation consists of three interrelated elements: modes, infrastructure, and operations. In terms of the environment, sustainable transportation emphasizes the reduction of pollution and noise, as well as resource management that supports transportation infrastructure.

The results of previous studies identify 12 main elements in MaaS planning, which include the integration of transportation modes, flexibility of fare options, and the provision of services through a single platform connecting various stakeholders. In addition, the utilization of digital technology enables the MaaS system to be more oriented toward user demand, with features such as service personalization, integrated registration, and integrated payment mechanisms. With better integration between public and private transportation services, MaaS has the potential to increase the attractiveness of bundle-based mobility and create a more efficient and seamless travel experience for the public. The general public will also be more interested if there are discounts outside peak hours. Younger users strongly want MaaS, but they are very price-sensitive. Possible MaaS business mechanisms include the sale of MaaS analytics data, transaction fees, and advertising. Ticket bundling is one example. One important step in technical support for enabling MaaS is the improvement of legislation and collaboration. Regardless of socio-demographic variables, public transportation modes (the backbone of MaaS) are the most important for users. The public chooses modes based on their experience, so habits and travel patterns are very important when choosing a plan. Due to a lack of facilities, car- and bike-sharing are less popular.

This research aims to achieve several objectives. First, to identify and analyze transportation integration and its implementation in supporting services. Second, to analyze the impact of digitalization and IoT (Internet of Things) in supporting sustainable transportation. Third, to identify and analyze the impact of digitalization in the transportation sector, such as social traffic management, network management systems, and social economics. Fourth, to analyze what collaboration between public transportation managers and integrators (Public-Private Partnership) looks like.

RESEARCH METHOD

Thematic analysis is a data analysis method used to recognize patterns or themes from data collected by researchers (Braun & Clarke, 2006). This method is very effective in cases where research aims to deeply investigate qualitative data in order to

uncover relationships between patterns and the development of phenomena from the researcher's point of view (Fereday & Muir-Cochrane, 2006).

As a new concept, particularly in the field of transportation, this research collected data and information in the area from 2021 to 2023. This research aims to understand the development of Mobility as a Service (MaaS) in Jakarta and the Jabodetabek region as a satellite area that supports the movement of passenger mobility in daily activities as well as other activities. This research uses a qualitative approach with thematic analysis methods and data triangulation to obtain a comprehensive understanding.

Data collection was carried out through three main stages. First, desk research to review the development of MaaS in Jabodetabek, urban transportation policy, the concept of sustainable transportation, as well as related literature and journals from both domestic and international sources. Second, in-depth interviews and Focus Group Discussions (FGDs) with academics, practitioners, stakeholders, and transportation operators to explore perspectives related to the implementation and challenges of MaaS. Third, observation and documentation related to the development of transportation technology in Jabodetabek, including the collection of visual data such as text and images, as well as pattern and theme analysis of the data obtained.

Several variables that form the conceptual framework of this research include MaaS, NMS, Transport Blueprint, IoT, Mobility Journey, Socioeconomics of Transport, and Sustainable Transport. Data analysis was then conducted thematically with three main focuses. First, infrastructure analysis, which covers information technology (IT) systems, transportation modes, transportation data, operational activities, and regulations supporting MaaS. Second, analysis of actors and consumers, which highlights user types, travel purposes, mobility habits, relationships with service providers, and the communication channels used. Third, value proposition analysis, which focuses on service integration, connectivity between transportation modes, and service coverage in the Jabodetabek region.

Through this method, the research not only seeks to understand existing conditions, but also to evaluate the relevance of policies, the role of integrators, and the potential development of MaaS to support sustainable transportation in urban areas.

RESULTS AND DISCUSSION

Data Description

When discussing the issue of dependency, private motorized vehicles (both cars and motorcycles) are considered to provide comfort, speed, and status to their owners. This condition is influenced by the growth of settlements on the outskirts of the city, which results in longer travel distances (Hendratno, 2009). Traffic congestion reflects disputes over the use of urban transportation infrastructure. The absence of adequate transportation facilities is a common cause of traffic congestion in cities. The current road network has a smaller area than the urban areas it must serve, which is an additional cause. It is impossible to stop the high growth of movement in urban

areas. However, transportation facilities are very limited, which disrupts mobility and accessibility. Traffic congestion causes environmental damage, economic losses, declining public health, and other social problems.

Along with urban growth and increasing mobility, the community's need for intermodal transportation has become increasingly important in the modern era. Intermodal transportation is not only about mobility; it also makes cities more environmentally friendly and comfortable to live in. Combining various modes allows the public to choose the mode of transportation that best suits their needs, reducing traffic congestion, air pollution, and even transportation costs.

More broadly, the concept of multimodal transport consists of two modes (Krygsman, 2004), described as follows: Connecting Modes, namely modes connected before the main mode (known as the "access mode") and after the main mode (known as the "egress mode"). Main Modes, namely the mode used for the longest and most significant portion of a trip compared to other modes. Multimodal Network is a transportation network structure that connects various modes with different hierarchies, including main routes and feeder routes. This network has varying access and speed depending on the distance traveled. Mode Transfer Facilities with Different Networks: These are transfer points between two types of modes from two different types of networks. Mode Transfer Facilities with Different Networks: Parking areas that facilitate the transfer from private vehicles to public transportation, for example, the connection between road, river, and rail networks. Policy: A regulatory framework for governing public transportation performance, including planning, implementation, and policy management (Garrison & Levinson, 2005).

Public transport authorities, public transport operators, any mobility service operators, technology companies, MaaS companies, or other actors from the banking or telecommunications industry can take on the role of MaaS provider and integrator. This depends on the local situation and many factors, such as the strength of established transportation services, user readiness, institutional organization, and the legal framework for transportation services.

Research Findings

The DKI Jakarta Provincial Government has combined stations with various other types of transportation, such as TransJakarta, MRT, LRT, and online motorcycle taxis, through an integrated station concept. Notably, this integration covers physical aspects, such as facilities and routes, as well as the payment system. The revitalization of four main stations, Tanah Abang, Juanda, Senen, and Sudirman, is the first step of this plan. The addition of public facilities such as information boards, directional signs, and road markers was included as part of this improvement. The area around the stations was also transformed into a Transit-Oriented Development (TOD) zone. Cooperation between the DKI Jakarta Provincial Government, MRT, and Kereta Api Indonesia (KAI) produced this integration project. The goal is to increase the use of public transportation and reduce congestion in Jakarta by integrating more routes.

There are several transportation integrations that have been carried out in Jakarta (Afrianti et al., 2024):

Physical Integration: The purpose of this integration is to make it easier and more convenient for the public to reach their destinations. TransJakarta, one of the main public transportation services in DKI Jakarta, has an extensive network covering 220 stops (halte), 13 corridors, and 47 different routes. However, only 19 stops, or 8.6% of the total stops in the TransJakarta network, are directly connected to the MRT, LRT, and KRL (commuter rail). In this regard, pedestrian bridges (Jembatan Penyeberangan Orang/JPO) directly connect stations and stops.

Payment System Integration: Combining the payment systems for all types of public transportation in DKI Jakarta has great potential to reduce travel costs for Jakarta residents. Public transportation customers only need to use a single ticket to access various types of modes within a certain time period, using a top-up system with integrated payment. JakLingko, a development of OK-Otrip, is one of the integrated payment systems already in use in Jakarta. JakLingko utilizes various types of transportation, including the MRT, LRT, KRL Commuter Line, KAI Airport Rail Link, and toll road payments in the Jabodetabek region. In addition, it has integrated routes, management, and payment within the integrated transportation system.

Schedule Integration: The arrival and departure schedules of public transportation are integrated to reduce queues at stations and stops. With the Moovit application, residents of DKI Jakarta can easily switch between transportation modes. This application displays arrival and departure times, as well as information about arrival and departure schedules. In addition, schedule information for each mode of transportation can also be found at bus stops or stations; however, these schedules only display information for a specific mode at a specific location, such as at TransJakarta stops or KRL stations. The MRT has a 10-minute headway every day, while the LRT also has a 10-minute headway every day. During peak hours, the KRL has a headway of 5-10 minutes, while during off-peak hours, the headway is 30 to 60 minutes.

In addition, Rosyid et al. (2022) add that the success of public transportation system development in Jakarta is influenced by several factors, such as: the consolidation of angkot (minivan) operators joining TransJakarta; the momentum of the MRT and LRT launches in 2019; the improvement of the public transportation system in the DKI Jakarta region in cooperation with private parties such as the KRL Commuter Line; efforts to provide environmentally friendly fleets through electric bus trials by TransJakarta, with a vision of an entirely electric bus fleet by 2030; and improvements in pedestrian facilities, such as the Kendal Tunnel, which connects the KRL station, MRT Jakarta, Airport Rail Link, and TransJakarta stops.

The researchers also conducted field observations and Focus Group Discussions (FGDs) involving three main actors in the transportation integration ecosystem. These findings also revealed a number of obstacles still faced by transportation managers, users, and regulators alike.

Public Transportation Managers

The main problem stems from the lack of first-mile-last-mile (FM-LM) feeder services, which causes long waiting times and passenger buildup at transportation hubs. This is exacerbated by the low speed of modal transfers, particularly during peak hours, making public transportation users prone to being late for work or school.

In addition, limited infrastructure, such as minimal bus/angkot passenger boarding and alighting areas (laybays), causes congestion at modal transfer points. Managers also face challenges in terms of expensive infrastructure investment due to limited land availability in Jakarta, while fleet provision during peak hours remains inadequate. Another obstacle is the fleet management system, which is not yet fully integrated online, disrupting operational effectiveness.

Public Transportation Users

From the perspective of public transportation users, problems arise from the lack of accurate route and schedule information available in applications. Although supporting technology exists, application reliability is often disrupted, causing user confusion.

Waiting rooms that are full during peak hours reduce comfort, while staff services that are not responsive enough to complaints worsen the user experience. Self-service kiosks that would make it easier for users to make bookings without staff assistance are not yet widely available.

Regulators

From the regulators' perspective, the main problem lies in the management of transportation hub areas, which is not yet optimal. Differences in systems and operators hinder payment integration, while the process of transferring subsidies from the central government to regional governments faces administrative obstacles, especially for regions that do not yet have a regional-owned enterprise (BUMD) or public service agency (BLU). In addition, the absence of national regulations governing service integrators, fee management schemes, and private sector involvement in transportation integration slows development.

The process of physical integration and service system integration are still running separately; although some hubs already have physical facilities such as Transit-Oriented Development (TOD), collaboration between the government and the private sector has not been optimally established. The issue of land provision for modal integration is also a major challenge, given the high cost of land and the transportation budget burden, which reaches approximately 10% of DKI Jakarta's Regional Original Revenue (PAD).

These findings underscore the importance of closer coordination among the three main actors, managers, users, and regulators, to close the gap between policy plans and actual implementation in the field.

DISCUSSION OF RESEARCH RESULTS

Understanding the role of the regulator is a crucial aspect in efforts to realize transportation integration in

Jabodetabek. Although various policies have been formulated, implementation in the field still faces various challenges that hinder the achievement of a holistic transportation system. To explore the role of the regulator further, a focus group discussion was held, bringing together various parties. This activity was organized together with the Center for Transportation and Logistics Studies (Pustral) of Universitas Gadjah Mada (UGM) to discuss strategies and policies that support the strengthening of transportation integration in Jabodetabek. This discussion aimed to provide a comprehensive understanding in the context of the company where the researchers work, which operates in the field of transportation technology. The resource persons who participated in this discussion came from various units of the Ministry of Transportation, namely: the Transportation Policy Agency (BKT); the Directorate of Land Transportation (HUBDAT); the Directorate General of Railways (DJKA); and the Jabodetabek Transportation Management Agency (BPTJ).

The results of the discussion focused on several related issues, each containing solutions and follow-up recommendations proposed by the resource persons, presented in Table 1.

Novelty

By examining the integration of advanced technology in MaaS, this research demonstrates the important role of integrators, shows the use of Network Management Systems for effective mobility, and emphasizes the socio-economic and sustainability impacts of transportation integration. This method improves the Jabodetabek transportation system and produces a more effective and sustainable mobility platform.

CONCLUSION

The results of the research show that Mobility as a Service (MaaS), a technological innovation in mobility and transportation integration, plays an important role in integrating transportation systems with advanced technologies such as APIs, the Internet of Things, and data analytics. The Network Management System (NMS) supports mobility by providing real-time traffic analysis and information, which helps in transportation management. All parties expect smooth multimodal travel that improves comfort and efficiency. In Jabodetabek, transportation integration offers many benefits, such as reducing congestion and improving accessibility.

Production and public welfare increase as a socio-economic result of transportation integration. By providing better information and optimal traffic management, the relationship between social traffic management and network management systems improves the efficiency of passenger travel. Therefore, MaaS, as a technological advancement, not only combines transportation but also ensures sustainable transportation.

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