The Development of a SMART Suburban Transit System for Public Transportation Service Providers and Services Users in Chiang Mai

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Abstract

Public transportation plays a pivotal role in ensuring mobility for individuals who lack access to private vehicles, facilitating their seamless travel within and between urban and rural areas. Moreover, it enhances accessibility by providing low-income individuals with a means to reach essential services and opportunities, thereby promoting social equity and inclusivity. However, the public transportation system in Chiang Mai continues to face challenges in devising effective solutions to adequately meet the evolving needs of its users. This study aimed to investigate the public transportation service drivers' and users' opinions on current suburban public transportation services in Chiang Mai, develop a SMART Suburban Transit System for Public Transportation Service Providers and Services Users in Chiang Mai, and explore the level of user satisfaction with the implementation of the SMART Suburban Transit System. The research sample comprised 1,000 passengers and 20 drivers selected through convenient sampling. Additionally, a sample of 150 participants was recruited through purposive sampling. This included 100 regular public transportation app users, 40 drivers, and 10 staff members from Baan Tawai Transit Service Co., Ltd. All participants possessed Android-based mobile phones. Data were collected using two types of questionnaires for assessing opinions and satisfaction, as well as semi-structured interviews. The data were analyzed using descriptive statistics including mean and standard deviation. The results revealed that users' attitudes towards suburban public transportation services in Chiang Mai had a low overall mean of 1.89. Frequency and reliability emerged as the primary concern, followed by travel time, accessibility and convenience, driver behavior, and price. Service providers expressed concerns about the proliferation of ride-hailing services such as Grab Car, which posed a significant challenge to suburban public transportation, reducing market share and revenue. The absence of government support further weakened the competitive position of suburban public transportation services. To address these challenges, a SMART Suburban Transit System was developed, comprising three components: a web-based platform for service providers, an Android-based mobile application for drivers (BTTS Application), and an Android-based mobile application for users (BaanTawai Application). After implementation, user satisfaction with the system was moderate, with a mean of 3.34 and a standard deviation of 0.33. This indicates that the system effectively addressed the concerns of users and service drivers, improving the overall experience of suburban public transportation in Chiang Mai. The study's findings highlight the challenges faced by the public transportation system in Chiang Mai, particularly in meeting the evolving needs of users. The development and implementation of the SMART Suburban Transit System demonstrate the potential of technology-driven solutions to improve the convenience, reliability, comfort, and safety of its services.

Keywords: Smart Suburban Transit System, Mobile Application, User Satisfaction

Introduction

Chiang Mai, Thailand's second-largest metropolis after Bangkok, is a vibrant cultural and natural center in the northern region. It serves as a hub for economic activity, education, and tourism, attracting a significant influx of individuals seeking educational opportunities, relocation, employment, career advancement, and family reunification (Nagastrira, 2004). With this influx of migrants, the public transportation system plays a pivotal role in facilitating their daily commutes, connecting them to various parts of the city, and supporting their overall well-being. However, Thailand's infrastructure development has historically prioritized transportation

infrastructure, such as road widening, elevated roads, and overpasses, while neglecting transportation system management. This has resulted in an inefficient public transportation system that has been unable to meet the needs of the population, leading to an increase in the use of private vehicles for travel (Chalermpong, 2019). Despite the lack of promotion of public transportation system development, numerous studies have been conducted on service provision and public transport utilization behavior (Sattasopat, 2001; Polsararuk, 2008), impacts of public transport system provision (Srisinlapanan, 2006), problems in public transport management in the Chiang Mai metropolitan area (Saosaovaphak et al., 2011; Koodsela, 2016; Kawsaard, 2018; Patsamarn, 2020), demand and public transport systems suitable for the Chiang Mai metropolitan area (Upayokin, 2001; Patiphanthakan, 2007), and the feasibility of organizing a public transport system in the Chiang Mai metropolitan area (Borisutthiyangkun, 2006; Nawapanun, 2007). Nevertheless, the public transportation system in Chiang Mai continues to face challenges in finding effective solutions.

Technology has emerged as an indispensable tool in our daily lives, empowering us to overcome complex challenges and improve our overall well-being. Innovation will be meticulously crafted and developed to devise solutions that effectively address the obstacles we encounter, including those within the public transportation system. In Thailand, the incorporation of real-time location data and the development of public transportation apps stand as two notable examples of technology's transformative impact on public transit. Real-time location data enables cities to optimize bus routes and allocate resources more efficiently, leading to improved reliability and reduced wait times for passengers (Chawuthai et al., 2023; Siangsuebchat et al., 2021; Sirisombat et al., 2024). Public transportation apps, on the other hand, provide users with comprehensive information on routes, fares, and real-time updates, enhancing the overall user experience and making public transit more accessible and convenient (Tuaycharoen et al., 2016; Apasrawirote, 2017). The benefits of real-time location data extend beyond operational efficiency to the user experience. Moreover, public transportation apps can provide users with comprehensive information on routes, fares, and real-time updates. Passengers can access real-time bus locations, estimated arrival times, and alternative routes, empowering them to make informed decisions about their journeys. This enhanced transparency and accessibility make public transit more convenient and user-friendly, encouraging ridership and reducing reliance on personal vehicles.

Rot queues, also known as small pickup trucks with an added roof painted in five different colors or a 13-seat minibus, are fixed-route public transport vehicles that connect the city of Chiang Mai to its surrounding districts and vice versa. These vehicles are stationed at various points, including Chang Phuak bus station, Kad Luang bus station, and Chiang Mai Gate bus station, to pick up passengers. According to the Department of Land Transport (2017), suburban public transportation plays a pivotal role in facilitating commuting between urban and suburban areas, particularly in suburban regions. In Chiang Mai, where poverty is prevalent (Thai People Map and Analytics Platform, 2023), public transportation remains an affordable option, especially for individuals with limited financial resources. However, despite its importance, the suburban public transportation system has not undergone substantial improvements to align with the evolving needs and standards of users (Office of Transport and Traffic Policy and Planning, Ministry of Transport, 2017).

Prior research has primarily examined public transportation within the Chiang Mai municipality. This study, however, investigates the challenges of suburban public transportation services from the perspectives of service providers and users. The aim is to develop a SMART suburban transit system that addresses their needs. Leveraging technological advancements, this system enhances the quality of life for service providers and offers transportation

services that align with user requirements. Additionally, its implementation promotes social equity in transportation affordability, contributing to Chiang Mai's Smart City aspirations, particularly in the domain of Smart Mobility.

Research Objectives

This research project is guided by the following two objectives:

1. To investigate the public transportation service drivers' and users' opinions on current suburban public transportation services in Chiang Mai.

2. To develop a SMART Suburban Transit System for Public Transportation Service Providers and Services Users in Chiang Mai.

3. To explore the level of user satisfaction with the implementation of the SMART Suburban Transit System.

Methods and Materials

Population and Sample Group

To investigate the public transportation service drivers' and users' opinions on suburban public transportation services in Chiang Mai, 1,000 passengers and 20 drivers of Baan Tawai Transit Service Co., Ltd. were selected by convenient sampling method for data collection through questionnaires and interview, respectively in the first phrase. Furthermore, 150 users who utilize the SMART Suburban Transit System were selected through a purposive sampling method, ensuring that all participants possessed Android-based mobile phones in order to explore the level of their user satisfaction in the second phrase.

Research Instrument Validity and Reliability

The user opinion questionnaire employs a five-point Likert scale and is structured into three distinct sections. The first section gathers demographic data about the user, such as age, gender, occupation, and frequency of public transportation use. The second section assesses user opinions of the existing suburban public transportation services in terms of frequency and reliability, accessibility and convenience, price, driver behaviour, and travel time. Users are asked to rate their level of opinion with each aspect on a scale ranging from "Strongly Disagree" to "Strongly Agree". The third section provides users with an opportunity to elaborate on their opinions or raise additional concerns regarding public transportation services. Furthermore, the interview questions directed towards 20 drivers of Baan Tawai Transit Service Co., Ltd. concentrate on four primary areas: revenue generation, competitive dynamics, governmental support, and potential solutions. Revenue-related questions which aimed to understand the changes in revenue over time, the factors influencing these changes, and the company's expectations for future revenue growth, competition-related Questions which sought to understand how competitors had affected the public transportation provider's market share, pricing, and overall performance, problem-related questions which aimed to identify the factors that hindered the company's ability to achieve its goals and to explore potential solutions, and solution-related questions which aimed to identify innovative approaches, technological advancements, and policy changes that could improve performance and overcome obstacles. The questionnaire and the interview questions were evaluated by three experts, which the IOC scores were 0.89 and 0.92 respectively.

How to Conduct Research

The research process could be divided into two phases as follows:

Phase 1: Investigating the public transportation service drivers' and users' opinions on current suburban public transportation services in Chiang Mai

To initiate the research, the researchers obtained approval from Chiang Mai Rajabhat University and presented their research objectives to the Chiang Mai Provincial Land Transport Office. This research also collaborated with Baan Tawai Transit Service Co., Ltd. to gather essential data on bus operations. To investigate the public transportation service drivers' and users' opinions on current suburban public transportation services, a survey was conducted among 1,000 passengers and semi-structured interviews were held with 20 drivers of Baan Tawai Transit Service Co., Ltd. This data informed the development of a storyboard outlining the construction process of the SMART suburban transit system. The system was developed using the Flutter framework and Dart language, utilizing Google's APIs for enhanced functionality, and followed the System Development Life Cycle (SDLC) methodology. The system architecture was illustrated in Figure 1.

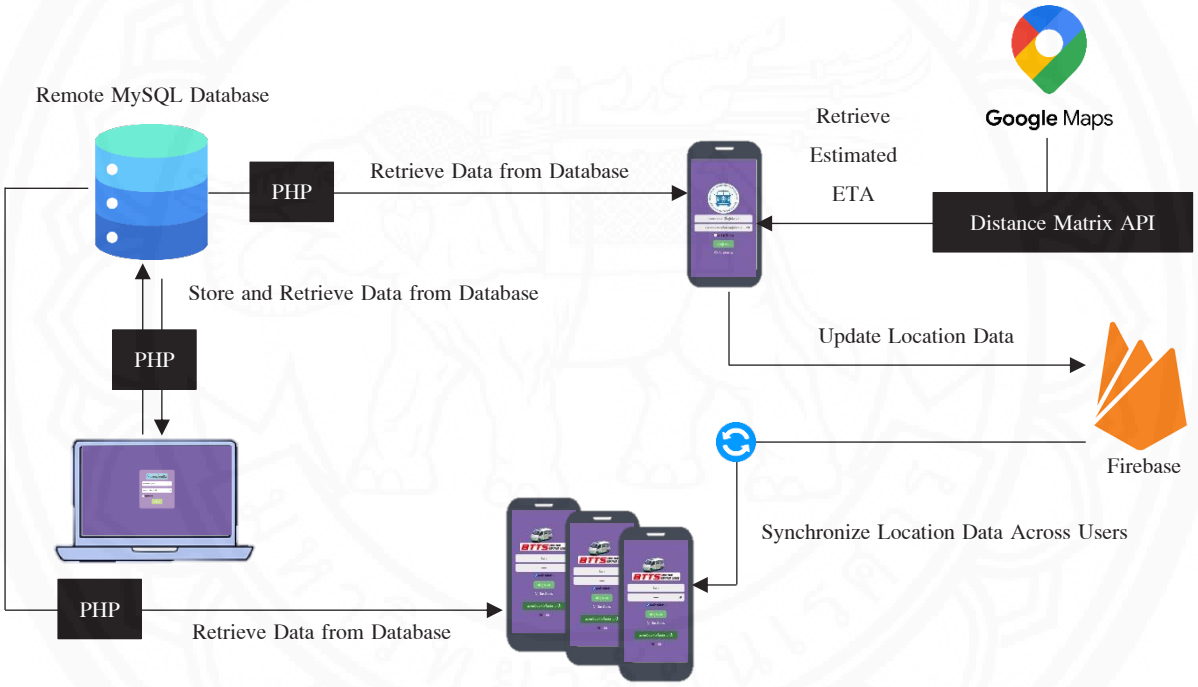

Figure 1 The System Architecture of a SMART Suburban Transit System for Public Transportation Service Drivers and Services Users in Chiang Mai.

After that, the smart suburban transit system was verified and assess for its quality by three computer experts. The overall technical property of the system was at the high level, as evidenced by the mean score of 4.38 and the standard deviation of 0.58.

Phase 2: Implementing a SMART Suburban Transit System for Public Transportation Service Providers and Services Users in Chiang Mai

Workshops were conducted for 150 individuals utilizing the public transportation application for users, 20 drivers of Baan Tawai Transit Service Co., Ltd. using the public transportation application for drivers, and 10 staff members of Baan Tawai Transit Service Co., Ltd. using a web-based platform for service providers.

Figure 2 Educate How to Use a SMART Suburban Transit System for Public Transportation Service Providers and Services Users in Chiang Mai. (Arunsirot et al., 2024b)

To evaluate the effectiveness of the SMART Suburban Transit System in Chiang Mai, a comprehensive questionnaire was developed, covering aspects such as frequency, reliability, accessibility, convenience, pricing, driver behavior, and travel time. This questionnaire was consistently used throughout the study's phases. Additionally, a user-friendly manual and infographic were created to guide application users through technical procedures. The applications for both drivers and users were conveniently made available on Google Play, ensuring accessibility and ease of use.

Data Analysis

The study employed a questionnaire to investigate the users' opinions towards the suburban public transportation in Chiang Mai and to assess the satisfaction levels of application users with the SMART Suburban Transit System in Chiang Mai. The questionnaire was analyzed to calculate the mean and standard deviation of each item, utilizing a Likert scale to measure satisfaction levels from highest to lowest. The satisfaction levels of the application users were interpreted as follows:

4.50 – 5.00	Very High
3.50 – 4.49	High
2.50 – 3.49	Moderate
1.50 – 2.49	Low
1.00 – 1.49	Very Low

Results

1. Public Transportation Service Providers' and Users' Opinions on Current Suburban Public Transportation Services in Chiang Mai

1.1 The users' opinions regarding current suburban public transportation services in Chiang Mai

Based on data collected through a questionnaire administered to 1000 users, Table 1 presents a summary of the users' opinions regarding current suburban public transportation services in Chiang Mai.

Table 1 The Users' Opinions Regarding Current Suburban Public Transportation Services in Chiang Mai

	Questionnaire Items	Mean	S.D.	Level of Opinions
	1. Frequency and Reliability			
1.1	The frequency of buses is convenient for my travel needs.	1.40	0.26	Very Low
1.2	The buses are generally on time, making it easy for me to arrive at my destination as planned.	1.20	0.12	Very Low
1.3	The timetables provide sufficient information for me to plan my trips effectively.	1.20	0.12	Very Low
1.4	The buses are reliable and I can count on them to get me to my destination.	1.40	0.26	Very Low

Table 1 (Cont.)

Questionnaire Items	Mean	S.D.	Level of Opinions
1.5 I can easily find out when the next bus is coming.	1.20	0.12	Very Low
Sub Total	**1.28**	**0.18**	Very Low
2. Accessibility and Convenience			
2.1 The bus stops are conveniently located, making it easy for me to access the system.	1.20	0.12	Very Low
2.2 The buses are comfortable and provide a pleasant travel experience.	2.60	0.52	Moderate
2.3 The buses are clean and well-maintained.	3.10	0.57	Moderate
2.4 The buses are accessible to people with disabilities.	1.00	0.00	Very Low
2.5 There are clear and noticeable signs for pick-up and drop-off areas.	1.20	0.12	Very Low
Sub Total	**1.82**	**0.27**	**Low**
3. Price			
3.1 The fare structure is reasonable and affordable.	3.90	0.32	High
3.2 The suburban public transportation services offer payment options that are convenient for me.	2.20	0.32	Low
3.3 The suburban public transportation services provide value for money.	3.80	0.42	High
3.4 I can use my phone or smart card to pay for my fare.	1.20	0.12	Very Low
3.5 The fare structure is clearly displayed for passengers.	1.20	0.12	Very Low
Sub Total	**2.46**	**0.26**	**Low**
4. Driver Behaviour			
4.1 The suburban public transportation drivers are courteous and professional.	3.40	0.79	Moderate
4.2 The suburban public transportation drivers follow traffic laws and regulations.	2.20	0.32	Low
4.3 The suburban public transportation drivers are attentive and polite.	2.00	0.32	Low
4.4 The suburban public transportation drivers are respectful of passengers' time.	1.80	0.32	Low
Sub Total	**2.35**	**0.44**	**Low**
5. Travel Time			
5.1 The suburban public transportation services provide a quick commute once on board the bus.	2.80	0.32	Moderate
5.2 The buses are generally on time, making it easy for me to arrive at my destination as planned.	1.20	0.12	Very Low
5.3 The suburban public transportation services offer real-time tracking of vehicles.	1.00	0.00	Very Low
5.4 The SMART Suburban Transit System allows me to plan my trips more efficiently due to its predictable travel time.	1.20	0.12	Very Low
Sub Total	**1.55**	**0.14**	Very Low
Total	**1.89**	**0.26**	**Low**

Based on the data presented in Table 1, an analysis of the users' opinions towards suburban public transportation services in Chiang Mai reveals a low overall mean of 1.89. Specifically, the passengers expressed the highest level of concern regarding frequency and reliability, with a mean score of 1.28. This was followed by travel time (mean = 1.55), accessibility and convenience (mean = 1.82), driver behaviour (mean = 2.35), and price (mean = 2.46).

Moreover, the passengers provide further elaboration on specific concerns, including overcharging of service fares for tourists both Thai and foreign visitors, inconsistent schedules and frequent delays, extended waiting

times, limited service coverage, and the absence of effective complaint channels. These issues hinder system improvements and contribute to the users' reliance on private vehicles.

1.2 The public transportation service drivers' opinions regarding current suburban public transportation services in Chiang Mai

In addition to the questionnaire survey, data was gathered through interviews with 20 drivers. The interview questions were organized into four main categories: revenue generation, competitive dynamics, governmental support, and potential solutions. The interview findings revealed that drivers had experienced a significant decline in revenue, estimated at approximately 70%, primarily due to competition from private transportation services such as Grab and Maxim, as well as the economic downturn and reduced travel demand during the COVID-19 pandemic. Drivers anticipated that revenue would continue to decline in the future. Despite these challenges, drivers expressed optimism about the potential benefits of mobile applications similar to Grab. They believed that such applications could enhance their services by allowing passengers to track bus locations and providing drivers with advance knowledge of the number of passengers to be picked up along their routes. Drivers acknowledged that these applications could improve their competitiveness with private transportation services. However, they also indicated a lack of financial resources to invest in such technologies. The data could be presented in Table 2.

Table 2 The Analysis of the Suburban Transportation Provider in Chiang Mai

Strengths	Weaknesses
■ Experienced drivers ■ Cheaper fares	■ Less flexibility in scheduling due to the fixed-route service ■ No convenient pickup and drop-off locations ■ High fuel costs ■ Vehicle maintenance and repair expenses ■ Competition from private public transportation services
Opportunities	**Threats**
■ Invest in technology to improve efficiency and accessibility ■ Provide training and support to drivers to improve customer service ■ Advocate for government policies that support public transportation ■ Use GPS tracking to optimize routing and reduce travel times ■ Develop real-time information systems to provide passengers with up-to-date information on bus arrivals and departures	■ Competition from private public transportation services, such as Grab and Maxim ■ Economic downturn ■ Rising fuel costs ■ Reduced travel demand and travel style due to the COVID-19 pandemic ■ The absence of governmental support ■ Lack financial support ■ Government policies and regulations

2. Developing a SMART Suburban Transit System for Public Transportation Service Providers and Services Users in Chiang Mai

Based on data above, a smart suburban transit system has been developed for public transportation service providers and service users in Chiang Mai. The system offers the following features:

Table 3 The Relationship between the Users' Concerns and the SMART Suburban Transit Features

The Users' Concerns	SMART Suburban Transit Features
1. Frequency and Reliability The user expressed a very low level of satisfaction with the frequency and reliability of the suburban public transportation system. They found that the buses were not frequent enough, were often late. Additionally, they did not feel that they could count on the buses to get them to their destination on time.	■ Provide the active timetable for passengers: This feature provides passengers with the route and the number of active buses ■ Calculate the estimated distance for reaching the pick-up location: This feature calculates the estimated distance between the bus's location and the passenger's pickup location. ■ Allow passengers to request transportation when they are at the pick-up location: This feature allows passengers to request transportation when they are at their pickup location.
2. Travel Time The suburban public transportation services generally provide a quick commute once on board the bus. However, the buses are not always on time. The services do not offer real-time tracking of vehicles. It does not allow passengers to plan their trips more efficiently due to its unpredictable travel time.	■ Allow drivers to share their location: This feature allows drivers to share their real-time location with the system. ■ Update the location of drivers in the database and broadcast it to passengers: This feature updates the location of drivers in the system's database and broadcasts it to passengers so that they can track the location of their assigned driver. ■ Track the user's location using GPS: This feature uses GPS to track the real-time location of the user (either driver or passenger).
3. Accessibility and Convenience The suburban public transportation system provides a low level of accessibility and convenience. The bus stops are inconveniently located, making the system hardly accessible. and there are no clear and noticeable signs for pick-up and drop-off areas.	■ Allow passengers to set starting points: This feature allows passengers to specify their pickup location.
4. Driver Behaviour The suburban public transportation drivers are generally courteous and professional. However, there are some areas where their performance could be improved. One area of concern is the drivers' adherence to traffic laws and regulations. The drivers often speed and run red lights. This behavior is dangerous and puts passengers at risk. Another area of concern is the drivers' attentiveness and politeness. The drivers are often distracted and inattentive. Finally, the drivers are often late and unreliable. This behavior is inconvenient and frustrating for passengers.	■ Provide information about the driver and car registration number: This feature provides passengers with information about the driver assigned to their request, including the driver's name, photo, and car registration number. ■ Send feedback for service quality improvement: This feature allows users to provide feedback on the quality of the service they received.
5. Price The suburban public transportation system does not offer convenient payment options. Additionally, the fare structure for suburban public transportation is not clearly displayed, which can lead to confusion and frustration among passengers who are unsure of how much they will have to pay for a fare.	■ Provide scheduled services: This feature provides information about scheduled transportation services, including the starting and ending times of each service as well as the fare structure and payment options.

Hence, a smart suburban transit system for public transportation service providers and services users in Chiang Mai system was subsequently conceptualized as a multifaceted platform comprising three interconnected components:

1. **A Web-based Platform for the Service Provider:** This system consists of a web application which can be accessed online at https://admin.cmurbantransit.online. The features are as follows:

1) **Route Management:** this module enables service providers to efficiently manage and optimize transportation routes, ensuring optimal coverage and connectivity.

2) **Bus Schedule Management:** the platform facilitates the creation and management of detailed bus schedules for each designated route. This ensures timely and reliable service for commuters.

3) **Driver and Vehicle Information Management:** the system maintains comprehensive records of driver credentials and vehicle details, promoting accountability and safety.

4) **User Feedback and Complaint Handling:** the platform provides a dedicated channel for users to submit complaints and suggestions, fostering transparent communication and continuous improvement.

Additionally, Figure 3 presents the screens of a web-based platform for the service provider.

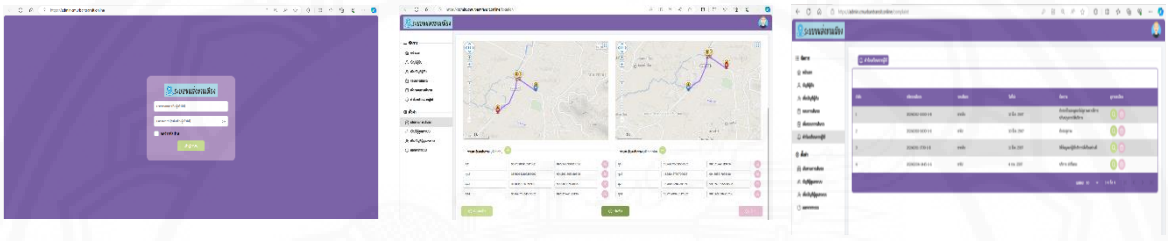

Figure 3 The Screens of a Web-based Platform for the Service Provider.

2. An android-based mobile application for drivers, named as "BTTS", which is accessible for download from Google Play. The features are as follows:

1) **Real-Time Vehicle Location Tracking:** this module enables drivers to transmit their real-time location to a central database, enhancing visibility and facilitating efficient dispatching.

2) **Service Request Management:** the application provides a seamless interface for drivers to receive and manage service requests from users, encompassing both passenger transportation and parcel delivery.

3) **Service Record Management:** the application automatically summarizes service records for both passenger and parcel transport, and facilitating daily revenue tracking.

Furthermore, Figure 4 presents the screens of an android-based mobile application for drivers.

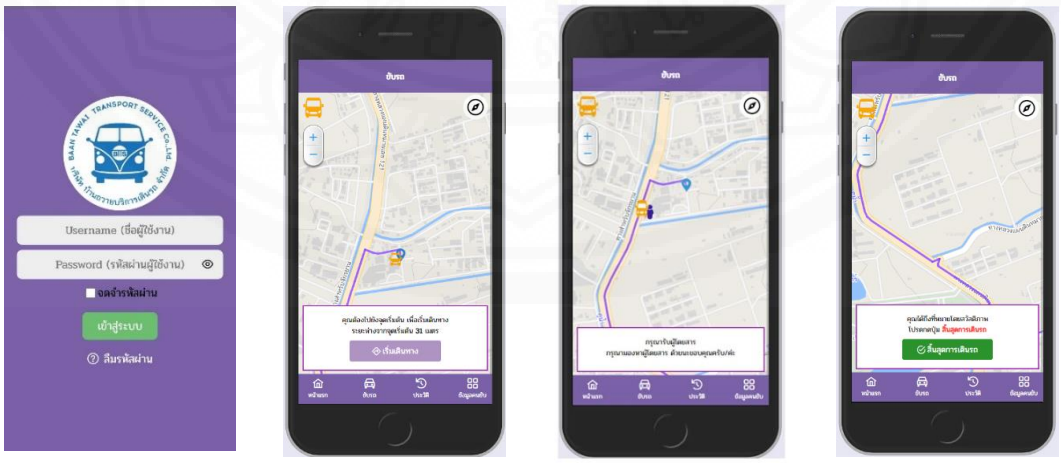

Figure 4 The Screens of an Android-based Mobile Application for Drivers.

3. An Android-Based Mobile Application for users, named as "BaanTawai", which is accessible for download from Google Play. The features are as follows:

1) **Public Transport Schedule Information:** the application provides comprehensive and up-to-date information on public transport schedules throughout Chiang Mai province.

2) **User Location Sharing:** riders can conveniently share their pickup locations with the database, enabling drivers to locate and respond to service requests promptly.

3) **Service Provider Tracking:** the application allows riders to track the real-time location of service providers, ensuring transparency and enhancing service reliability.

4) **Feedback and Complaint Submission:** the application provides a dedicated channel for riders to submit complaints and suggestions to the relevant transport authority, fostering continuous improvement and service quality enhancement.

5) **Tourist Information:** the application provides the information about tourist attractions, the up-to-date events, the news in Chiang Mai.

Moreover, Figure 5 presents the screens of an android-based mobile application for users.

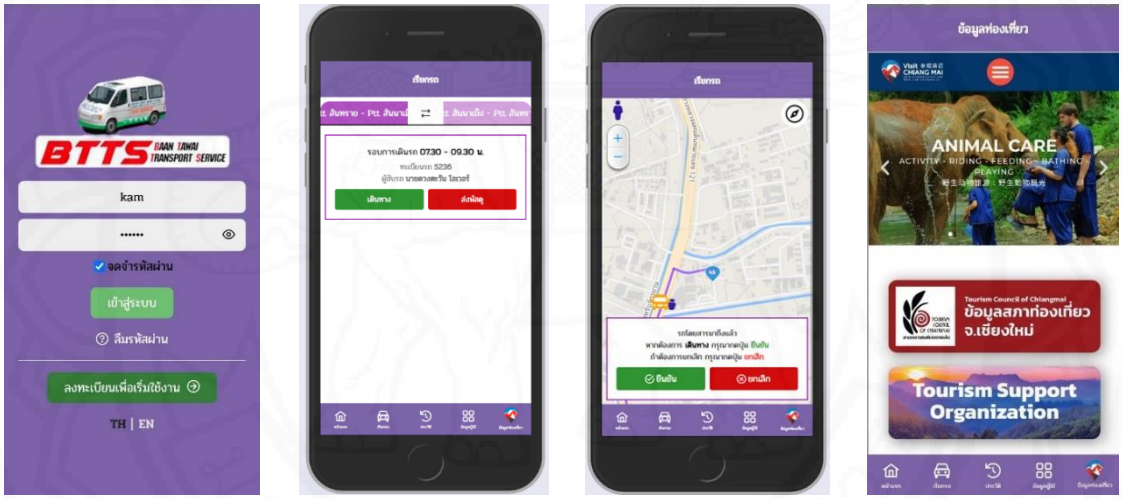

Figure 5 The Screens of an Android-based Mobile Application for Users.

3. The Evaluation of User Satisfaction with the SMART Suburban Transit System for Services Users in Chiang Mai

Following the implementation of the SMART Suburban Transit system, the research team conducted an evaluation to assess user satisfaction. A total of 150 users participated in the evaluation, and their responses are summarized in Table 4.

Table 4 The Users' Opinions Towards Using the SMART Suburban Transit System for Public Transportation Service Providers and Services Users in Chiang Mai

	Questionnaire Items	Mean	S.D.	Level of Opinions
1.	**Frequency and Reliability**			
1.1	The frequency of buses is convenient for my travel needs.	1.40	0.26	Very Low
1.2	The buses are generally on time, making it easy for me to arrive at my destination as planned.	3.20	0.23	Moderate
1.3	The timetables provide sufficient information for me to plan my trips effectively.	4.40	0.22	High
1.4	The buses are reliable and I can count on them to get me to my destination.	3.40	0.46	Moderate

Table 4 (Cont.)

Questionnaire Items	Mean	S.D.	Level of Opinions
1.5 I can easily find out when the next bus is coming.	4.80	0.52	Very High
Sub Total	**3.44**	**0.34**	Moderate
2. Accessibility and Convenience			
2.1 The bus stops are conveniently located, making it easy for me to access the system.	3.80	0.40	High
2.2 The buses are comfortable and provide a pleasant travel experience.	2.60	0.32	Moderate
2.3 The buses are clean and well-maintained.	3.10	0.20	Moderate
2.4 The buses are accessible to people with disabilities.	1.00	0.00	Very Low
2.5 There are clear and noticeable signs for pick-up and drop-off areas.	3.20	0.22	Moderate
Sub Total	**2.74**	**0.23**	Moderate
3. Price			
3.1 The fare structure is reasonable and affordable.	3.90	0.40	High
3.2 The suburban public transportation services offer payment options that are convenient for me.	3.20	0.32	Moderate
3.3 The suburban public transportation services provide value for money.	3.80	0.32	High
3.4 I can use my phone or smart card to pay for my fare.	3.20	0.22	Moderate
3.5 The fare structure is clearly displayed for passengers.	4.20	0.20	High
Sub Total	**3.66**	**0.29**	**High**
4. Driver Behavior			
4.1 The suburban public transportation drivers are courteous and professional.	3.40	0.79	Moderate
4.2 The suburban public transportation drivers follow traffic laws and regulations.	3.20	0.32	Moderate
4.3 The suburban public transportation drivers are attentive and polite.	3.20	0.32	Moderate
4.4 The suburban public transportation drivers are respectful of passengers' time.	2.60	0.52	Moderate
Sub Total	**3.10**	**0.49**	**Moderate**
5. Travel Time			
5.1 The suburban public transportation services provide a quick commute once on board the bus	2.80	0.32	Moderate
5.2 The buses are generally on time, making it easy for me to arrive at my destination as planned.	3.80	0.30	High
5.3 The suburban public transportation services offer real-time tracking of vehicles.	4.60	0.20	Very High
5.4 The SMART Suburban Transit System allows me to plan my trips more efficiently due to its predictable travel time.	3.80	0.30	High
Sub Total	**3.75**	**0.28**	High
Total	**3.34**	**0.33**	Moderate

Table 4 presents the results of the user satisfaction evaluation for the SMART Suburban Transit system implemented in Chiang Mai Province. The overall user satisfaction score was 3.34 (SD = 0.33), indicating a moderate level of satisfaction. The mean scores for all aspects were higher than the mean scores before the implementation of the SMART Suburban Transit System. The findings indicate that the SMART Suburban Transit System has significantly improved public transportation services in Chiang Mai. The higher satisfaction scores indicate increased frequency and reliability, accessibility and convenience, price competitiveness, improved driver behavior, and reduced travel times.

Discussion

This study aimed to investigate the public transportation service drivers' and users' opinions on suburban public transportation services in Chiang Mai, develop a SMART Suburban Transit System for Public Transportation Service Providers and Services Users in Chiang Mai, and explore the level of user satisfaction with the implementation of the SMART Suburban Transit System. A preliminary survey was conducted to identify the specific needs and pain points of service providers and users towards the current suburban public transportation services in Chiang Mai. The findings informed the scope of the SMART Suburban Transit System's development which was conceptualized as a multifaceted platform consisting of three interconnected components: Web-based Platform for Service Providers, android-based mobile application for drivers, and android-based mobile application for riders. Furthermore, the System Development Lifecycle (SDLC) was meticulously followed throughout the development process. As the system met the needs and preferences of all concerned users in designing the system, their satisfaction with the implementation of the public suburban transit system was at a moderate level, with the mean of 3.34 and the standard deviation of 0.33. The SMART suburban transit system empowers users with a suite of features that address their concerns. Passengers can access real-time bus schedules and estimate pickup distances, ensuring timely arrivals and efficient planning. Convenient pickup requests and customizable starting points enhance accessibility. Scheduled services and transparent fare structures eliminate confusion and frustration. Passengers receive driver information and can provide feedback, fostering accountability and improving driver behavior. Real-time vehicle tracking and GPS location sharing enable efficient trip planning and reduce travel time uncertainty. Enhanced safety features allow passengers to report incidents and provide feedback on driver adherence to traffic laws, promoting a safer and more responsible transportation system. This corresponded with Arunsirot et al. (2024a) that application development based on SDLC is systematic and sequential, resulting in standard efficiency of the system and effectiveness of use.

According to Aungkhavaimongkol (1992), public transportation plays a pivotal role in the transportation ecosystem of Chiang Mai. However, the sector grapples with challenges pertaining to inadequate management, system instability, and insufficient government oversight. To address these challenges, it is crucial to develop a system for improving the efficiency of public transportation management in Chiang Mai. Therefore, this research proposes a technology-driven solution in the form of an online platform to augment the existing public suburban transportation system. The developed platform encompasses a comprehensive suite of functionalities tailored to both drivers and passengers. Administrators can delineate ride routes, ensuring drivers adhere to designated paths. Passengers can conveniently request rides by specifying their locations on an interactive map. Drivers are notified of passenger locations via pop-up prompts, facilitating efficient ride coordination. Passengers can monitor ride progress in real-time and cancel requests if necessary. Drivers conclude trips by activating an "end trip" button, triggering passenger feedback collection for service quality improvement. The implementation of the platform has significantly enhanced the management of public suburban transportation in Chiang Mai. This is consistent with Thangpreecharparnich (2022) who conducted a study on a mobile application for real-time bus route tracking using GPS technology. The findings indicated that the application effectively met the needs of users in several key areas: learning ability, error recognition, user satisfaction, user-computer interaction, and navigation. The application's implementation resulted in tangible benefits, including time savings, cost reduction, increased service efficiency, and enhanced business competitiveness. These findings align with the broader body of research on the use of technology to improve public transportation systems. By leveraging GPS technology and mobile

applications, transportation providers can enhance the user experience, optimize operations, and gain a competitive advantage in the market. Also, it was consistent with Sangaunwong (2023), investigating the factors influencing the successful implementation of a mobile application designed to enhance the quality of public transportation services in Saraburi province. The study identified several key factors: creating a positive passenger experience, instilling confidence in users, ensuring passenger accessibility, and establishing regularity and reliability. These factors were found to have a significant impact on the convenience and safety aspects of the application, ultimately contributing to its successful adoption and use by the local population. The findings of this study align with previous research on the importance of user-centric design and the provision of reliable and convenient services in the context of public transportation. By addressing these factors, transportation providers can enhance the overall quality of their services and encourage greater public transportation usage. In conclusion, it could be stated that this research demonstrates the transformative potential of technology in addressing challenges faced by public transportation systems. The developed platform has effectively improved management efficiency, enhanced user experience, and laid the groundwork for further advancements in the provision of public suburban transportation services in Chiang Mai.

Conclusion and Suggestions

In response to the inadequacies of the existing suburban transportation system, this study explored the opinions of public transportation service drivers and users in Chiang Mai to inform the development of a SMART Suburban Transit System that effectively addresses user needs. The findings revealed that user concerns primarily centered on frequency and reliability, followed by travel time, accessibility and convenience, driver behavior, and price. The SMART Suburban Transit System was designed to address these concerns through a comprehensive suite of features, including an active timetable for real-time bus information, estimated distance calculation for improved accessibility and convenience, on-demand request for timely and convenient service, starting point customization for increased accessibility, scheduled services for transparency and convenience, driver information for enhanced safety and accountability, service quality feedback for continuous improvement, real-time driver location sharing for improved travel planning, GPS tracking for accurate and reliable information, and an updated driver location database for enhanced transparency and reduced uncertainty. These advancements have transformed the suburban transportation industry, significantly enhancing the convenience, reliability, comfort, and safety of its services. The integration of online platforms has revolutionized the interaction between users and drivers, leading to an overall improvement in the public transportation experience.

Operational Recommendations were as Follows

1. **Enhance System Functionality and Content:** Provide ongoing support for the system's development to expand its capabilities and content offerings.

2. **Promote System Adoption:** Implement public relations campaigns to disseminate information about the application and encourage its adoption by other suburban transportation routes.

3. **Develop iOS Application:** Create a mobile application compatible with the iOS operating system to cater to a wider user base.

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