EasyChair Preprint

№ 15311

Analysis of Mobile Applications Supporting Public Transport in Smart Cities on the Example of Poland

Monika Ziółko and Sylwia Kołodziej

October 28, 2024

ANALYSIS OF MOBILE APPLICATIONS SUPPORTING PUBLIC TRANSPORT IN SMART CITIES ON THE EXAMPLE OF POLAND

ABSTRACT

Background: The main purpose of this article is to present the role played by urban mobility apps, as well as to learn about their functions and the impact they have on public transportation. In addition, the social survey conducted in the article made it possible to learn about the opinions of mobile app users, as well as to identify areas for improvement.

Methods: A social survey based on an online survey of people using public transportation services. The survey sample included travelers living in different areas of Poland, which enabled more accurate inferences to be made about the general population.

Results: The results of the survey showed that the vast majority of respondents use mobile applications to support public transportation, the most frequently used application by respondents is Jakdojade, it is also the best rated by them. The most important functionalities for users are determining the route from point A to point B, the availability of timetables and the ability to determine the total travel time. The survey also indicated areas for improvement, such as increasing the availability of the app to include more cities and expanding the function of purchasing various types of tickets.

Conclusions: The results can be a valuable source of knowledge not only for application developers, but also for transportation carriers, city decision-makers, as well as anyone interested in the topic of smart cities. The original study was based on a proprietary online survey with a sample of 1,000 respondents.

Keywords: public transport, applications, Smart City, municipal public transport, public transportation

INTRODUCTION

In recent years, there has been a tremendous development of technology and information tools, affecting many areas of the economy. In view of the changes taking place, the concept of Smart City has emerged, which is very broad and difficult to define clearly. The term is most often identified with innovative cities, focusing on development based on the use of information and communication technologies (ICT). These tools aim to increase the efficiency of all processes taking place, improve the flow of information and take care of the environmental balance, so as to consequently improve the standard of living of residents [Mohanty 2016]. Put another way, smart cities take advantage of new technological solutions, improving the efficiency of the use of existing resources while reducing negative environmental impacts.

The latest technologies are being used to make it easier for passengers to move around the city [Kanthavel, Sangeetha and Keerthana 2021; Kuo, Leung i Yan 2023]. Thanks to special applications for smartphones, travelers can check the current position of a bus or streetcar, the time of its arrival at a given stop or the approximate travel time between two locations [Vakula and Raviteja 2017].

In recent years, there has been a tremendous development of technology and information tools, affecting many areas of the economy. In view of the changes taking place, the concept of Smart City has emerged, which is very broad and difficult to define clearly. The term is most often identified with innovative cities, focusing on development based on the use of information and communication technologies (ICT). These tools aim to increase the efficiency of all processes taking place, improve the flow of information and take care of the environmental balance, so as to consequently improve the standard of living of residents [Mohanty 2016]. Put another way, smart cities take advantage of new technological solutions, improving the efficiency of the use of existing resources while reducing negative environmental impacts.

The latest technologies are being used to make it easier for passengers to move around the city [Kanthavel, Sangeetha and Keerthana 2021; Kuo, Leung and Yan 2023]. Thanks to special applications for smartphones, travelers can check the current position of a bus or streetcar, the time of its arrival at a given stop or the approximate travel time between two locations [Vakula and Raviteja 2017].

THE EVOLUTION OF DEVELOPING MOBILE APPLICATIONS SUPPORTING PUBLIC TRANSPORTATION

Applications that support getting around by public transportation, act like a travel assistant that knows the topography of the city in detail. When choosing the most advantageous route, they take into account not only fixed factors, but also parameters that change in real time, such as traffic congestion that causes vehicle delays. To make them as easy to use as possible, the developers strive to combine a clear and intuitive interface with rich functionality [Altexsoft 2018].

Once the back-end is designed, the application must be integrated with online maps, public transportation infrastructure, as well as with payment service providers and transaction processing networks, in case it offers the ability to purchase a ride ticket [Altexsoft 2018; Shaheen, Cohen, Zohdy and Kock 2016; Shaheen 2016].

Modern travel plenaries offer a range of functions, the most important of which are the following [Solecka and Kiciński 2022]:

- determining the optimal route between two points,
- presentation of the travel route on the map,
- display of timetable information,
- indicating the current location of the vehicle using GPS,
- calculation of total travel time.

Apps that support travel planning vary widely. Some of them can additionally enable [Solecka and Kiciński 2022]:

- purchase of traffic tickets - both single and season tickets,
- electronic payments,
- presenting information on vehicle delays in real time,
- as well as sending messages about possible changes in the course of individual lines,
- offline operation,
- selecting the number of transfers,
- indicating the location of nearby bicycle, motorcycle, scooter or car sharing points.

The selection of the most essential features is a key factor that influences users' perception of the application. However, even the most experienced developers cannot determine on their own whether their project will meet all the needs of the audience. To get a more accurate idea of the requirements of app owners, it is necessary to analyze the reviews left by them [Chen, Hassan and Xing 2021]. Platforms, such as Apple Store and Google Play Store, allow people to give feedback on how an app is performing by assigning star ratings and posting comments [Genc-Nayebi and Abran 2017; Aljrees et. al. 2024). Reviews usually

include a usage scenario, reports of possible bugs and requests to add new desired features [Panichella, Di Sorbo and Guzman 2015].

REVIEW OF EXISTING RESEARCH COVERING THE TOPIC OF URBAN MOBILITY APPLICATIONS

In order to make a sound analysis of the research results and draw relevant conclusions, a review of the available studies in the literature was conducted, which cover the topic of urban transportation support applications. In the world, research has been carried out for years on the use of the latest technologies to support transportation systems in cities. Cities around the world have studied the usability and popularity of mobile applications used in public transportation to improve their functionality and popularize this solution among users. An example is the research conducted in Australia [Foth and Schroeter 2010], Germany [Schmitz Bartsch and Meyer 2016; Kluth, Krempels, Terwelp and Wüller 2013], and the South African [Niemand and Chauke 2017]. They include comparisons of individual applications, analysis of additional features and are based on a case study of individual operators [Pawełoszek and Wieczorkowski 2023].

In Poland, urban mobility applications are as popular as they are worldwide. It has also been subjected to scientific studies and quantitative analyses in the literature. For example, a social survey was conducted in 2018 and its results were published in the scientific journal *Transport Miejski i Regionalny*, in an article entitled: "Implication of innovative mobile apps to improve the flow of people in cities on the implementation of sustainable transport and Smart City concepts" [Berlińska and Choma 2018]. It addresses topics related to urban logistics in the broadest sense, with a particular focus on the role of mobile applications that facilitate travel by public transport. The analysis was carried out on a group of 222 people whose main mobility destination was the Maria Curie-Skłodowska University in Lublin. The results of the study show that respondents most often get around the city using public transport - bus or trolleybus. Respondents considered Google Maps to be the most frequently used application (71.6%), followed by Jakdojade (60.8%) and Mobile MPK (51.4%) [Berlińska and Choma 2018]. In addition, the analysis in terms of the usability of individual software functions showed that the least important aspect for users was the streamlining of the payment process, while the key aspect for them was the efficient search for connections between locations.

Another article that addresses the topic of urban mobility applications is the 2020 publication entitled 'Multi-criteria evaluation of urban public transport travel planning applications'. Similarly to the previous work, the article was published in the monthly *Transport Miejski i Regionalny* [Solecka and Cholewa, 2020]. It presents the most popular urban travel planning applications, which were first compared based on their functions.

For research purposes, an online survey questionnaire was used, which was addressed to the residents of the Malopolska voivodship. A total of 180 people took part. Thanks to the analysis, the most popular application, which turned out to be Jakdojade, was selected. The survey also showed that as many as 97% of respondents rated the operation of the used travel planners as "good" or "very good". In addition, respondents indicated which functions of the app they felt were most important. The most frequent answers to this question were ease of use (13.4%) and information about lines departing from a given stop (12.6%).

The topic of mobile applications in relation to public transport is also addressed in the article 'Analysis of the use of selected passenger communication tools in public transport systems', which was published in 2017. In it, the author of the text discusses websites providing passenger transport services in selected Polish cities and analyses the most popular mobile applications dedicated to passengers [Miłaszewicz 2017]. The article does not compare the individual applications, but provides a brief description of each. However, it is worth noting that several years have passed since the material was published and the information contained therein has become outdated.

ANALYSIS OF THE MOST POPULAR SOFTWARE THAT SUPPORT MOBILITY IN POLAND

There are many mobility apps in the world, while their popularity changes with time, user preferences, as well as many other factors. Based on a review of numerous online rankings among the most popular urban mobility apps in Poland, it is possible to list them in order to get a complete picture [Solecka and Cholewa 2020; Solecka and Kiciński 2022 b; Bielińska-Dusza, Hamerska and Żak 2021]:

- Jakdojade,
- Mobile MPK,
- KiedyPrzyjedzie,
- Transportoid,
- E-podróżnik.

Each of the above-mentioned software applications has slightly different functions and a unique interface. It is impossible to identify the best option, as perceptions of a particular application may vary depending on individual user preferences. The evaluation usually takes into account aspects such as up-to-date timetables, the ability to calculate a route, the inclusion of transfers, the option to purchase a ticket, the ability to set a minimum transfer time, real-time updates on delays or information on scheduled travel times. Table 1 presents a comparison of individual applications facilitating public transport in Polish cities.

Table 1. Urban mobility applications operating in Poland

	Jakdojade	**Mobile MPK**	**KiedyPrzyjedzie**	**E-podróżnik**	**Transportoid**
Number of downloads - Google Play Store	5 mln+	1 mln+	100 tys.+	1 mln+	500 tys.+
Google Play Store user rating	4,3 ★ (140 000 opinions)	4,4 ★ (52 100 opinions)	3,8 ★ (1 210 opinions)	3,7 ★ (18 200 opinions)	2,7★ (11 000 opinions)
Number of cities / operators served	50 cities	56 cities	95 operators	26 cities /1 400 operators	60 cities
Comparison of the functions of the different applications					
Timetable	+	+	+	-	+
Routing from A to B	+	+	-	+	+
Ticket option	+	-	-	+	-
Taking account of transfers	+	+	-	+	+
The option of setting a time for transfer	+	+	-	-	+
Data update in real time	+	+	+	-	-

Source: own work based on [Google Play Store 2024; Jakdojade 2024; mMPK 2024; KiedyPrzyjedzie 2024; e-podróżnik 2024].

The applications presented above are not the only ones that make travelling within Poland easier. There are many different types of such software, but not all of them are as popular. What is undeniable, however, is that all urban mobility applications contribute to more convenient and accessible travel by public transport. They have seen tremendous development in recent years and these applications are gaining more and more useful features, constantly expanding their spectrum of services. Urban mobility applications not only make travelling much easier, but also contribute to the promotion of sustainable forms of transport. Thanks to them, citizens are more willing to use city bicycles or electric scooters, which are many times a faster and more economical alternative to cars over short distances.

RESULTS OF THE RESEARCH ON THE PREFERENCES OF POLISH URBAN RESIDENTS IN THE SCOPE OF APPLICATIONS

The main objective of the research was to find out users' opinions on mobility applications in Polish cities in order to assess their functionality, ease of use and identify areas for improvement. In addition, the results of the survey were intended to help in the process of improving existing software.

The basis of the whole research process will be the research questions, which will allow a better understanding of the main aspects influencing the selection, evaluation and use of applications in the context of different factors. The following questions are formulated at the outset:

- Which app is most frequently chosen by respondents using public transport services?
- What impact does frequency of public transport use have on the evaluation of the performance of the mobile app?
- Does the place of residence of respondents influence their use of apps to support the functioning of public transport?
- What function of the app is rated the highest by respondents?

Five research hypotheses were determined based on the above questions:

H1: Jakdojade is the most frequently selected app by respondents.

H2: Frequency of public transport use influences the evaluation of the performance of the mobile app.

H3: Respondents' place of residence influences the use of urban mobility apps.

H4: According to respondents, the most important function of an urban mobility app is the ability to map a route from A to B.

In order to verify the hypotheses presented, appropriate analyses of the survey results will be carried out. Hypotheses 2 and 3 are alternative hypotheses and will be verified by statistical tests in the course of the study, while hypotheses 1 and 4 will be verified based on the percentage distribution or averages of the survey responses. The collected responses will provide valuable information to further development of urban mobility applications and improve the quality of public transport services.

Social research, more specifically a survey form, was used to conduct the analyses. It was designed using a Google form. The survey was conducted between 21 April 2023 and 14 May 2023. The target group was people who use public transport and, in particular, owners of apps that facilitate public transport travel. The selection of the research sample was purposive, meaning that respondents were selected based on the subjective assessment of the researchers. The purposive sample made it possible to identify actual users of urban mobility apps, whose

opinions and experiences were the main focus of the survey. The selection made the survey more targeted and allowed data to be collected from people with direct knowledge of the topic under discussion.

The survey involved 1,000 people from various regions of Poland, including 718 women (71.8% of respondents) and 282 men (28.2% of respondents). Respondents were divided into four age categories. The largest group was made up of people aged between 18 and 26, who were exactly 708 (70.8% of the total). The other categories were made up of those under 18, those aged 27-40 and those over 40. The size of each group was 30 (3%), 210 (21%) and 52 (5.2%) respondents, respectively. More than half of the respondents (58.9%) live in a city with more than 300,000 inhabitants, while the smallest number of people (7.3%) live in towns with between 150,000 and 300,000 inhabitants. In addition, 16.4% of respondents live in the countryside, 9.7% are stationed in a town with up to 50,000 inhabitants, while 7.7% reside in a town with between 50,000 and 150,000 inhabitants. The average respondent has a secondary education (40.4% of people) or higher education (55.5% of people). On the other hand, a small proportion of respondents have primary education (2.4%), lower secondary education (0.7%) and basic vocational education (1%). In addition, the respondents were divided according to the frequency of their use of public transport services.

Of those surveyed, 956 people use public transport services, while 893 declared that they use an urban mobility app on their phone. The above division was made possible by the use of filter questions at the beginning of the questionnaire and was intended to ensure that only owners of the apps would answer questions about their use. Such a procedure helped to select the target group, i.e. respondents with experience with this type of software.

The first hypothesis to be verified concerned the most frequently chosen application to support mobility on public transport. In this respect, the following hypothesis was formulated: "Jakdojade is the most frequently selected app by respondents". In order to verify it, respondents were asked to indicate the urban mobility app they use most often. After analysing the respondents' answers, the highest percentage of people responding use the Jakdojade app. This answer was indicated by as many as 644 people, representing 72.1% of all respondents. On the basis of the information obtained, the first hypothesis positively can therefore be verified.

The hypothesis that the frequency of use of the use of public transport influences the performance evaluation of the mobile app. The null hypothesis for this analysis is that there is no relationship between the frequency of use of public transport and the app's performance

evaluation. Table 2 shows the result of juxtaposing the two factors based on the Chi-square test of independence conducted.

Table 2. Frequency of use of public transport and evaluation of application performance

Frequency of use of public transport services	How would you rate the functioning of the application you are using?				
	Very bad	Bad	Average	Good	Very good
Every day	36	76	43	110	113
A few times a week	26	64	28	107	91
Less than a few times a week	23	44	15	53	64
χ^2 = 6,852906					**p = 0,552583**

Source: own work on the basis of the research carried out.

The results of the Chi-square test carried out do not provide grounds to reject the null hypothesis. The p-value is high enough to exceed the established critical significance level of 0.05. The study therefore does not confirm the existence of a statistically significant relationship between the frequency of use of public transport services and users' evaluation of the app.

In order to verify another null hypothesis, which read: "Place of residence does not influence the use of urban mobility apps", the answers to the question regarding the respondents' declarations regarding the use of urban mobility apps on their phone and the metric question regarding the respondents' place of residence were analysed. The alternative hypothesis assumed in this area was the statement: "Respondents' place of residence influences the use of public transport apps". Thanks to the Chi-square test of independence (Table 3), it was possible to statistically assess the validity of the hypotheses.

Table 3. Relations between place of residence and use of apps

Place of residence	**Do you use an urban mobility app on your phone that finds connections based on timetables?**	
	I use	**I don't use**
City with less than 300 000 inhabitants	337	38
City of over 300 000 inhabitants	556	25
χ^2 = 12,585517		**p = 0,0003887**

Source: own work on the basis of the research carried out.

On the basis of the Chi-square test carried out, the null hypothesis can be rejected and the alternative hypothesis accepted. According to the results obtained, there is a statistically

significant relationship between the size of the town in which the respondents live and the fact that they use the app. The study indicates that the larger the population of a city, the more often its residents use urban mobility apps.

The last hypothesis was formulated as follows: 'According to respondents respondents the most important function of the urban mobility is the possibility of designating the route z point A to B'. In order to verify this correctly, the most frequently occurring functions in the applications were collected and the interviewees were then asked to subjectively determine their relevance. The question used a numerical scale that included numbers between 1 and 5, where 1 meant 'not at all important' and 5 reflected 'very important'. Based on the collected answers, the average of the presented functions and the highest to the lowest. The resulting ranking is presented in Table 4.

Table 4. Importance of the various functions of the app for respondents

Function	**How important do you consider the different functions of the application to be? (1- not important at all, 5 - very important)**					**Average**
	1	**2**	**3**	**4**	**5**	
Possibility to determine route from A to B	9	14	58	121	691	**4,65**
Timetable	13	17	76	163	624	**4,53**
Information on total travel time	10	31	101	235	516	**4,36**
Real-time arrival time updates	18	31	114	195	535	**4,34**
Integration of different modes of transport	21	53	163	240	416	**4,09**
Determining a route without changing	40	68	182	219	384	**3,94**
Location detection	44	95	164	244	346	**3,84**
Offline use of applications	129	143	181	183	257	**3,33**
Possibility to buy a ticket for the journey	167	119	178	137	292	**3,30**
Avoidance of selected means of communication	135	176	263	169	150	**3,03**
Possibility of changing the language	374	159	201	80	79	**2,25**

Source: own work on the basis of the research carried out.

The data presented in Table 4 allows us to conclude that the possibility of mapping the route from A to B is given the greatest importance by the opinion leaders. This function was not only identified as 'very important' the most times, but also received the highest average score. The analysis therefore allows us to conclude that the last of the hypotheses posed is true. In addition, thanks to the results presented in the table, it is possible to rank the individual functions of the application according to their degree of usefulness to users. On the basis of the research carried out, the most important is the aforementioned possibility of mapping a route from A to B. The option to change language, on the other hand, is the least important to respondents. This is probably due to the fact that the default language used in

most applications is English, which is widely understood by a large number of people. Nevertheless, 8.8 % of respondents still consider this function as ‘very important’, so it should not be underestimated.

The public survey also included open questions, the first of which concerned the weakest aspects of urban mobility apps. Respondents are largely dissatisfied with the number of advertisements appearing in the apps, interfering with a comfortable user experience. The ticket purchase process, and in particular ticket validation, which is usually done by entering the side number of the vehicle, also proves problematic. Users of the app also point to a number of other problems, such as a lack of information on delays, hindered operation of the app or non-intuitive stop location signs. It is important to find appropriate solutions to help improve these aspects or eliminate the inconveniences associated with them altogether.

Respondents were also asked for suggestions for improvements that could be made to the aforementioned apps. Respondents shared many valuable ideas for potential improvements to the travel planning apps. Suggestions selected included purchasing tickets, displaying travel routes and stop locations, extending the app to smaller towns and cities, and introducing new, useful features. The proposed innovations have the potential to make a significant difference to the comfort of people using urban transport.

Although public transport apps are very popular among users, some respondents declared that they do not use them. The most common reasons cited were the use of traditional timetables, unfamiliarity with the apps, their lack of intuitiveness and bugs in the software.

As can be seen from the analysis above, there are many reasons why respondents do not use apps to support public transport travel. Traditional timetables are still sufficient for a large group of people, but the lack of awareness of the existence of modern solutions also influences their decision. Appropriate education on new technological tools and measures to improve the functioning and accessibility of individual applications are therefore necessary.

CONCLUSIONS

In the era of the Smart City, mobile applications to support communication play a key role in the path of urban transformation around the world. They are an indispensable tool for improving the quality of life of citizens and the efficiency of cities. These software applications facilitate access to information about timetables, routes and emerging delays, allowing public transport users to plan their journeys more comfortably.

The analysis carried out as part of this article has made it possible to identify differences between the available urban mobility applications in terms of their functionality, accessibility and degree of technological advancement. The author's survey, meanwhile, made it possible to find out the opinions of software users, as well as to identify areas for improvement.

The study verified all of the research hypotheses and obtained answers to the research questions. They provided new knowledge on the functioning of mobile applications supporting public transport in Poland. They revealed new relationships between the factors studied and outlined future research directions in this area.

There are a number of promising directions that can be considered for future research. Firstly, it is worth taking an interest in the accessibility and usability of the aforementioned applications for people with different needs, including disabilities. Innovative technological solutions should take into account all social groups, and public transport is no exception. Secondly, it is worth considering the impact of the use of urban mobility apps on congestion, greenhouse gas emissions and the quality of life of residents. Indeed, an analysis of the Smart City's impact on aspects of sustainability can provide important insights for urban decision-makers as well as designers of public transport systems.

However, it is important to remember that the development of mobility apps should not be an end in itself, but an integral part of a Smart City strategy. In the first instance, it is crucial to ensure access to well-functioning public transport for all residents, regardless of their technological sophistication or access to a smartphone. Any software improvements will only be of real benefit once the proper level of performance of traditional methods of communication is taken care of.

The conclusions and recommendations presented in this article are important primarily for public transport operators and mobile application developers. In the longer term, the analysis may also gain relevance for cities themselves and urban planning institutions. After all, effective public transport solutions are key to shaping smart cities that strive for resource optimisation, sustainability and improved quality of life for residents. The results of the research carried out can therefore be a valuable source of information and inspiration for further work on the development of public transport and Smart City projects.

REFERENCES

Aljrees, T., Umer, M., Saidani, O., Almuqren, L., Ishaq, A., Alsubai, S., Ashraf, I., 2024 Contradiction in text review and apps rating: prediction using textual features and transfer learning. PeerJ Computer Science (10, e1722).

Altexsoft, 2018, https://www.altexsoft.com/blog/engineering/public-transportation-apps-apis-and-platforms-maps-scheduling-trip-planning-and-mobile-ticketing/.

Berlińska, E., Choma, J., 2018, Implikacja innowacyjnych aplikacji mobilnych usprawniających przepływ osób w miastach na wdrażanie koncepcji zrównoważonego transportu oraz koncepcji SmartCity. Transport Miejski i Regionalny, pp. 30-35.

Bielińska-Dusza, E., Hamerska, M., Żak, A., 2021, Sustainable mobility and the smart city: A vision of the city of the future: The case study of Cracow (Poland). Energies 14(23), p. 7936.

Chen, Q., Hassan, S., Xing, Z., 2021, How should I improve the UI of my app? a study of user reviews of popular apps in the Google Play. ACM Transactions on Software Engineering and Methodology (TOSEM), pp. 1-38.

e-podróżnik, 2024, https://www.e-podroznik.pl/.

Foth, M., Schroeter, R., 2010, Enhancing the experience of public transport users with urban screens and mobile applications. (pp. 33). Enhancing the experience of public transport users with urban screens and mobile applications. In Proceedings of the 14th international academic mindtrek conference: Envisioning future media environments, pp. 33-40.

Genc-Nayebi, N., Abran, A., 2017, A systematic literature review: Opinion mining studies from mobile app store user review, Journal of Systems and Software, 125, pp. 207-219.

Google Play Store, 2024, https://play.google.com/store/apps.

Jakdojade, 2024, https://jakdojade.pl/krakow/trasa.

Kanthavel, R., Sangeetha, S. K., Keerthana, K. P., 2021, Design of smart public transport assist system for metropolitan city Chennai. International Journal of Intelligent Networks, 2, pp. 57-63.

KiedyPrzyjedzie, 2024, https://kiedyprzyjedzie.pl/.

Kluth, W., Krempels, K. H., Terwelp, C., Wüller, S., 2013, Increase of travel safety for public transport by mobile applications. International Conference on e-Business (ICE-B), pp. 1-9, IEEE.

Kuo, Y. H., Leung, J. M., Yan, Y., 2023, Public transport for smart cities: Recent innovations and future challenges. European Journal of Operational Research 306(3), pp. 1001-1026.

Miłaszewicz, B., 2017, Analiza wykorzystania wybranych narzędzi komunikacji z pasażerami w systemach komunikacji miejskiej. Autobusy: technika, eksploatacja, systemy transportowe.

mMPK, 2024, https://www.mmpk.info/o_aplikacji,12,.html.

Mohanty, S. P., 2016, https://www.researchgate.net/publication/306046857_Everything_You_Wanted_to_Know_About_Smart_Cities.

Niemand, C. J., Chauke, H., 2017, The use of mobile applications by public transport commuters in Gauteng, South Africa. South African Journal of Information Management 19(1), pp. 1-9.

Panichella, S., Di Sorbo, A., Guzman, E., 2015, https://ieeexplore.ieee.org/abstract/document/7332474.

Pawełoszek, I., Wieczorkowski, J., 2023, Trip planning mobile application: a perspective case study of user experience. Engineering Management in Production and Services 15(2), pp. 55-71.

Schmitz, C., Bartsch, S., Meyer, A., 2016, Mobile app usage and its implications for service management–empirical findings from German public transport. Procedia-Social and Behavioral Sciences (224), pp. 230-237.

Shaheen, S., 2016, Mobile apps and transportation: A review of smartphone apps and a study of user response to multimodal traveler information. UC Berkeley.

Shaheen, S., Cohen, A., Zohdy, I., Kock, B., 2016, Smartphone applications to influence travel choices: practices and policies. *UC Berkeley*.

Solecka, K., Cholewa, M., 2020, Wielokryterialna ocena aplikacji wspomagających planowanie podróży transportem publicznym w miastach. Transport miejski i regionalny, pp. 20-28.

Solecka, K., Kiciński, M., 2022, A multi-criteria evaluation of applications supporting Public Transport Users. Energies, pp. 15-25.

Subin, 2022, https://www.cronj.com/blog/trip-planner-app-development/.

Vakula, D., Raviteja, B., 2017, https://ieeexplore.ieee.org/abstract/document/8389288.

Zaichenko, M., 2022, https://maddevs.io/blog/tech-stack-to-build-transportation-apps/.