Analysis of Tools Supporting Travel Planning by Public Transport in Łódź

Stanisław Ejdys
Ignacy Moscicki's University of Applied Sciences in Ciechanów, Poland
https://orcid.org/0000-0003-4312-7880

corresponding author's e-mail: stanislaw.ejdys@pansim.edu.pl

Abstract: Today, as climate change becomes more and more visible, we need new, more sustainable transport solutions. One of them is travel planners, which are crucial in the process of moving around. The general availability of planners' travel and the ease of their use encourages more and more groups of people to use them. They consider the combination of different means of transport and optimise the user's journey in terms of parameters he selects, e.g., time, cost, ecological effect or the number of transfers or minimising the walking distance. This means that by making the right choice, we can travel responsibly. Awareness of this fact allows us to take care of the natural environment, promote sustainable transport, and, consequently, protect our planet for future generations. The article analyses IT tools – mobile and internet applications – supporting travel planning by various means of public transport in Łódź. The selection of travel planners for analysis was based on available studies, reports and internet rankings. Deductive reasoning was used to assess their usefulness for travel planning. The study ends with indications of what information in applications enabling travel planning is considered the most important, valuable and helpful for the user – traveller.

Keywords: public transport, trip planner, passenger

1. Introduction

In the face of growing ecological problems such as climate change and environmental pollution, more and more people are asking how they can travel sustainably. Fortunately, technology comes to our aid by offering travel planners that not only minimise the negative impact on the natural environment but are also one of the commonly used applications that help eliminate the barriers of ignorance and certainty when making decisions about means of transport and form of travel (Dyczkowska et al. 2023a). Awareness of this fact creates, on the one hand, new opportunities and, on the other hand, problems to be solved. It also allows you to look at travel planning anew as a multi-threaded process that greatly impacts the natural environment and the safety of travellers. All this is so that in the face of growing economic, social, and environmental challenges, we can live and travel better in the future. People worldwide want to travel faster, cheaper and more conveniently. However, I want to have the entire travel offer available from my phone/trip planner in every corner of the world.

In times of increased population migration, travel planners have become essential for planning journeys. They allow travellers to save time and increase travel comfort. Until recently, these were just timetables and signs with painted directions mounted in vehicles (https://www.jelbi.de/). Today, new technologies (Szajna et al. 2022) mean they become the traveller's navigator throughout the entire transport route. They provide a traveller with the necessary information and tips on an ongoing basis to reach their destination without any obstacles. Even if they are imperfect in their essence, their role and significance in making optimal transport decisions (Chamier-Gliszczyński 2012) is "worth its weight in gold" (https://www.plany.mobilnosci.pl/).

Of course, the development of digital technology and a higher standard of living have increased the requirements placed on these tools. As a result, travel planners have been created, raising the traveller service standard. They provide users with the necessary information regarding moving from one place to another. The journey is planned according to many criteria: the shortest travel time or route, the fewest transfers or the lowest price (Chamier-Gliszczynski 2016). As a result, the traveller can feel safe and be sure that he will reach the chosen destination without any problems.

Planners can be combined with navigation, providing access to current information about the journey at each stage. The main elements of a trip planner are a database containing geographic information (digital maps) relevant to trip planning and a database of models, i.e. algorithms that determine routes, as well as a user interface that allows interaction. Trip planners differ in the detailed solutions of the indicated elements.

Planners take the form of web-based tools available through a browser or applications for universal mobile devices (smartphones, tablets) or dedicated mobile devices (navigators) operating offline or applications for desktop computers. Some planners are available in more than one way. In such cases, there may be differences in functionality between the individual forms of access. The maps used in a given planner determine the maximum territorial scope of its operation. Currently available maps, including those created as part of voluntary

projects such as OpenStreetMap, often cover the entire world. Therefore, the level of data accuracy may vary depending on the region. Additionally, the travel planner itself may limit the territorial scope of planning by disabling such functionality in selected areas.

From a technical point of view, it is a universal platform that supports any predefined area. The main part of the planner is the server, to which queries are sent from so-called clients, i.e. query generators with their own interface. Using the client interface (on a computer or a mobile device such as a tablet or smartphone), travellers can send queries to the server by providing specific input data. Queries to the engine can be executed via a website and a mobile application on the Android system. The basic structure of the tool is shown in Figure 1.

Currently, travel planners have become a huge convenience in the process of moving around a selected area. Their general availability and ease of use encourage more and more people to use them and, consequently, to use public transport (Ejdys 2021). The growing interest in applications increases the offer of available travel planners on the market. On the other hand, increasing competition forces program creators to introduce innovative solutions and facilities for users constantly. Their further development and application will depend on the development of information technology on the one hand and the rapid equipping of vehicles with onboard computers on the other. The lack of a sufficient number of GPS transmitters and a system for monitoring the vehicle fleet and adopting the principle of open data are still barriers to developing and functioning mobile and internet applications in real time. From the user's point of view, these activities are slow and too slow concerning the announcements and declarations of transport organisers, the speed of changes in all fields of science and technology, and the pace of people's lives (Ejdys 2023).
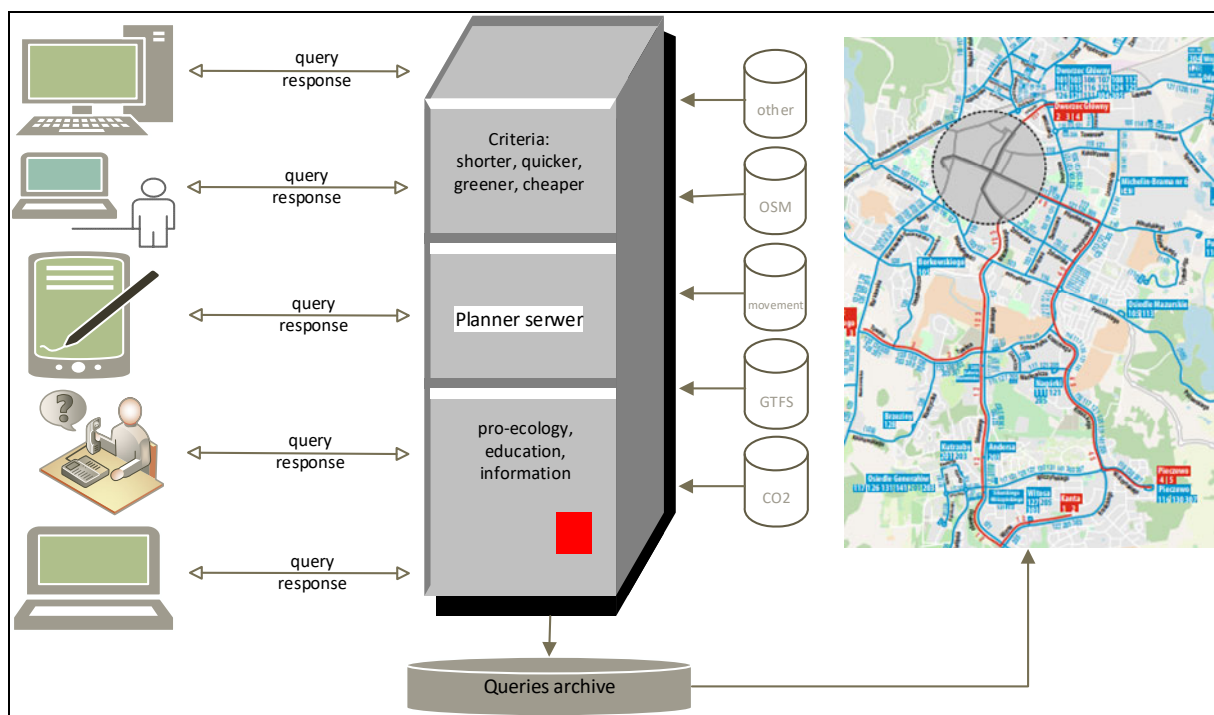

Fig. 1. Planner functional diagram

2. Travel Planners Available in Łódź

Travel planning in Łódź is possible thanks to various internet and mobile applications. The most popular are: JakDojade.pl, E-podróżnik.pl, Transportoid, MobileMPK. The selection of applications for the study was made based on available studies, reports and internet rankings. Some of the most popular applications were used for comparison. Based on a review of internet resources, they were compared in terms of their most important functions. The obtained results showed the functionality of each application and indicated those that are most often and most willingly used by users – Table 1.

Jakdojade is the most popular application for travel planning. It is a Polish web application. Available in the following systems: Android, iOS, and Windows Phone. Jakdojade consists of 3 main dashboards. The first dashboard contains timetables, where users can independently search for the timetable for the line or stop they are interested in. The second dashboard allows the user to buy a public transport ticket. The third dashboard contains a route search engine with the option of filtering. The application has the function of tracking the lo-

cation of public transport vehicles in real time. This function is available in the paid Premium version. In addition, the Premium version exempts the user from advertising. Additionally, it is equipped with, among others, a function that alerts you when you leave a public transport vehicle and allows you to place the most important timetables on the phone's main screen. Searching for routes also allows the traveller to choose preferred lines and set the minimum transfer time. The application has a filter for low-floor vehicles, largely aimed at disabled people using wheelchairs. In a route requiring a change to another mean of transport, the application provides the travel time separately for each stage of the journey, including the time to get to the stop and the waiting time for the mean of transport at the designated stop. The application has a function for planning journeys in public transport and rail transport. The application offers access to timetables for dozens of Polish cities (https://company.jakdojade.pl/o-aplikacji/).

Table 1. Travel planners available in Łódź

Lp.	The name of the trip planner	Access source
1	Jakdojade	https://company.jakdojade.pl/o-aplikacji/
2	Mobile MPK	https://www.mmpk.info/
3	E-podróżnik	https://www.e-podroznik.pl/
4	E-traveller	https://www.e-podroznik.pl/
5	MyBus online	http://www.taran.com.pl/mybusonline
6	Transportoid	http://transportoid.com/
7	Moovit	https://moovitapp.com/
8	Google Maps	https://www.google.com/maps
9	Kiedyprzyjedzie	http://kiedyprzyjedzie.pl/
10	Koleo	https://koleo.pl/

Mobile MPK – Polish mobile application created using Java technology and published by MobiCORE. It is available for Android and iOS systems. Mobile MPK, similarly to the Jakdojade application, consists of three main dashboards after opening. On the first dashboard, the user can add favourite stop and line timetables and favourite connections, which saves time when searching for frequently used routes. On the second dashboard, there is a list of elements that redirect us to: connection search engine, timetable from a given stop, available city bike stations nearby, address search engine, maps and the possibility of sending coordinates where the user is located. The last dashboard contains a connection search engine with the possibility of filtering routes. The software has two versions: a free basic Light version and a paid Pro version, the cost of which depends on the form of payment and the duration of the subscription counted in months. The main advantage of the Pro version is the lack of advertisements and the ability to add a timetable of your lines. Thanks to filters, the user can specify the maximum number of transfers, the maximum and minimum distance to the stop that must be covered, the minimum time for transfers, avoiding designated lines, public transport vehicles and the previously planned departure time. The application searches for connections only and exclusively for public transport connections. In the case of connections with transfers, Mobile MPK provides the time for each stage of the journey, along with the time to get to the stop and the waiting time for the mean of transport at the designated stop. After selecting the appropriate route filtering option, the program allows the user to search for low-floor vehicles. A major advantage is the ability to work offline. After downloading the timetable in advance, the user can use Mobile MPK without an internet connection. The program is enriched with a delay presentation function and informs the user about the actual departures and arrivals of public transport vehicles. The location function lets travellers check the available city bike stations. Mobile MPK allows to check public transport timetables for over 50 Polish cities (https://www.mmpk.info/).

E-podróżnik – the official mobile application of the Polish website e-podróżnik.pl. The program allows the combination of public and intercity transport and sells tickets for selected bus and railway connections. The ticket offer of the E-podróżnik application is limited to domestic and international tickets and does not include the option of purchasing a public transport ticket. The application has one dashboard, which directly contains a connection search engine and links to other application functions. The planner is equipped with travel filtering, thanks to which the passenger can specify the journey, assign restrictions related to the type of carrier, choose the comfort level imposed by the application, and sort by price or time. The user can also search only for such journeys for which tickets are sold online (https://www.e-podroznik.pl/).

The E-podróżnik application has "My Tickets" function, which stores pending, active, archived and cancelled tickets. In addition, the program allows for the advance entry of traveller data (name and surname, contact phone number, e-mail address, identity document and document number) and invoice data. When searching for a route with transfers, the E-podróżnik provides the user with information on total travel time, time of individual travel stages, waiting time for transfer, distance to the stop from the starting point, distance between transfer points, time to reach the stop, route including stops of a given communication line and information about the carrier. An interesting function of the program is the money box, which allows for early payment of money to individual accounts, for which the user can later directly purchase a ticket without using bank transfers. The user can access timetables for railway, bus, and minibus carriers. The application is free. It has timetables for public transport in about 30 cities in Poland. In addition, the E-podróżnik.pl application user can check the timetable for public transport abroad in countries such as Germany or the Czech Republic (https://www.e-podroznik.pl/).

MyBus online – the application is part of the Passenger Information System (PIS), part of the MUNICOM Premium software by Przedsiębiorstwo Usług Informatyki TARAN. The application is available for mobile phones with Android, Windows Phone and iOS systems. Unlike other applications, myBus online is adapted for blind people; this function works independently based on a continuous reading of the current GPS position, which is used to find the nearest stop. The application informs the blind user about the distance to the stop they must cover from their current location. In addition, if the service recipient is already at the stop, the program will read the public transport lines that depart from it and the current time. The main advantage of myBus online is that it tracks public transport vehicles via GPS. Thanks to this function, the user receives a more accurate time of the appearance of a mean of public transport at a given stop, i.e. real departure times, taking into account delays or accelerations of courses that are not planned in the timetable. The list of program functions is displayed to the user on the application's main screen. When searching for a route, the traveller can specify the maximum number of transfers. The application also has a notification function that the user must set off on the route to reach the designated stop on time. There are two modes available: online mode and offline mode. Unlike offline mode, online mode updates timetables on an ongoing basis and provides access to boards with the nearest departures. The application's main screen displays a list of program functions for the user. When searching for a route, the traveller can specify the maximum number of transfers. It is worth noting that the program uses QR codes at stops. The application is dedicated to public transport users in over 40 cities in Poland (http://www.taran.com.pl/mybusonline).

Transportoid – an application by FTL Software with timetables that works on Android, Windows Phone and iOS systems. The application consists of four dashboards. On the first one, the user can add favourite routes. The second one contains timetables for each stop in the city, the third one contains timetables for each mean of public transport, and the last dashboard contains a connection search engine. Transportoid allows the search for connections with a minimum transfer time, a maximum transfer time and a minimum distance to the stop that the traveller must cover. The application has a function for marking low-floor vehicles. It is equipped with passenger information only for means of public transport. Users using Transportoid are up to date with all changes in the functioning of public transport, including timetables. Each modernisation is updated on an ongoing basis. The basic version of the application is free of charge. People who want to use advanced functions, such as placing selected timetables on the dashboard, grouping stops and the GPS function, must pay in advance. The program allows you to set an individual reminder regarding purchasing a season ticket, and the application also allows you to work offline. The application offers access to timetables in 60 Polish cities (http://transportoid.com/).

Moovit – an Israeli mobile application using OpenStreetMap maps, supporting travel planning by public transport. The application is available for mobile phones with Android, iOS and Windows Phone systems. Moovit is one of the world leaders in mobile applications dedicated to public transport. The application consists of 3 main screens. The first desktop contains a connection search engine, favourite destinations (suggested: home, work) and an option allowing users to order an Uber. The second screen shows the stops located near the user on a map. The last screen contains timetables for bus, tram and train lines. The Moovit application allows monitoring of the journey; after setting the destination in advance, the person using the application will be notified about getting off before the final stop and after the end of the journey and can also rate the quality of services offered by public transport. The passenger using the application receives information about detours or changes in the timetable. Moovit has a travel plan function that allows you to filter routes. The service user can search for a connection with the minimum number of transfers and the shortest walking distance to the stop. The application also allows users to choose their preferred means of transport from bus, train, tram, bicycle and electric scooter. In the case of journeys with transfers, the application will inform the user about the length of the individual stages of the journey, the length of the transfer time, the distance to the stop and

between stops that the user has to cover, what's more, it will present the entire route on a map, taking into account the starting and ending point and the place of transfer. The application is free of charge. Its database has passenger information for 94 countries, 3,000 cities in the world, and 25 Polish cities (https://moovitapp.com/).

Google Maps is a mobile application created by Google. Initially intended for people moving on foot or by individual transport. It has recently been dedicated to public transport users, thanks to the extension called Google Transit. Available for phones with Android, Windows Phone and iOS. After starting the Google Maps application, the main screen displays a connection search engine and a map on which the user's current location is marked. When the user enters the starting and ending points, the application automatically searches for a route for various means of public transport. Also, it presents all possible options for covering this route and the estimated travel time. While searching for a connection, the user can choose the preferred means of transport, the best route, the connection with the fewest transfers and the minimum distance from the starting point to the stop. The application also has a route filter, which displays only and exclusively public transport vehicles adapted for disabled passengers. Google Maps navigates the traveller from the starting point to the stop for connections with transfers, presents the total travel time and travel time for each stage, displays all the stops on a given line, and additionally determines the distance to the stop or between stops that the traveller must cover. The application allows you to combine travel by public transport with city bikes. The application is free and has directions for public transport in over 15,000 cities worldwide (https://www.google.com/maps).

Kiedyprzyjedzie.pl – is the official application of the system operating under the same name, combining the functions of a dynamic passenger information system and a tool for managing a fleet of public transport vehicles. It is available for mobile phones with Android, Windows Phone and iOS systems. The program provides the user with information about the actual arrival times of a public transport vehicle at a previously indicated stop in the form of a virtual board. Kiedyprzyjedzie.pl only informs passengers about public transport lines that will appear at the stop within 4 hours. It does not provide information about the course of a given line. Despite the information about the actual arrival times, the user cannot track the location of the public transport vehicle on the map. The application is dedicated to people living in small and medium-sized towns. It has a route search engine, but when the starting and ending point of the journey is entered, the program redirects the user to the Google Maps application. Unlike the others, the application does not have the option of filtering routes. It works in 70 cities (http://kiedyprzyjedzie.pl/).

KOLEO – is the first information and sales platform in Poland integrating all rail carriers in Poland. It is a completely Polish product based on Polish technology. The availability of the KOLEO application on mobile devices has been refined in terms of readability and ergonomics during a series of UX/UI tests, thanks to which the application allows for quick, safe and very convenient ticket purchase for a selected connection. The application meets all expectations regarding the EC1371/2007 regulation and accessibility requirements, including the WACG standard. Purchasing a ticket through the application and platform does not generate additional costs than the ticket price. The purchased ticket (including monthly and quarterly) is still visible in the application (https://koleo.pl/).

The Koleo mobile application for iOS and Android devices offers a ticket exchange or refund function, known from the browser version of the service. This allows you to change the date of your journey or the list of passengers more quickly, even when you are away from home, even on the day of your journey. To exchange or refund a ticket in the KOLEO mobile application, go to the ticket details and select the option of your choice: exchange or refund – depending on the needs. To return a ticket, confirm the decision in the dialogue box that appears. If we decide to do so, the money will be immediately transferred to your KOLEO account, which can be used for future journeys. The exchange option provides even more variants: you can exchange your ticket for any other journey with the same carrier. This applies even to group journeys or tickets for transporting luggage or a dog. This operation is also possible for connections with transfers – even when trains of different companies are planned to be used (https://koleo.pl/).

3. Comparative Analysis of Selected Travel Planners

Business practice shows that travel planners are assessed using standard software quality criteria. At the most general level, these are the following criteria:
– functional scope (usability),
– ease of use,
– reliability,
– efficiency,
– ease of maintenance.

Analysing scientific studies (Bielański 2016, Celiński et al. 2015, Chen et al. 2013, Cholewa 2020, Dinko et al. 2021, Gacek 2018, Jackiva et al. 2023, Jaszkiewicz et al. 2010, Koźlak 2020, Li 2012, Łoziński 2021, Solecka et al. 2020, Wolański 2022, Wang et al. 2021, Woźniak et al. 2015, Woźniak et al. 2018), one can conclude that planners should also be assessed using more detailed criteria related to this class of systems (Staniuk et al. 2022). The proposed criteria are divided into three groups corresponding to the triad of communication search engine modules:
– user interface,
– data model,
– search algorithm.

Currently, we can observe different approaches to evaluating available travel planners. Taking into account the criterion of spatial accessibility of using the application, Ratajczak and Zmuda-Trzebiatowski presented an analysis of the functionality of 8 publicly available planners, which could be used to plan a trip within the Poznań agglomeration (Ratajczak et al. 2017). Loidl and Hochmair, in turn, analysed 35 planners available in English, German or Dutch. Bryniarska and Gacek (Bryniarska et al. 2018, Gacek 2018) evaluated the travel planners in terms of their usefulness for public transport users. The triad of assessments indicated a large diversification of the planners' functionality regarding the number of available criteria for determining the travel route.

A broader approach to evaluating these tools was presented in the work of Ratajczak and Zmuda-Trzebiatowski. The authors assessed the occurrence of diversity in the scope of information provided to the user. However, the same authors assessed the quality of the generated routes only to a small extent, i.e., using the example of several subjectively selected routes. In turn, in the work of Loidl and Hochmair, the quality of the generated routes was not addressed. This work focused on the issue of taking into account safety criteria. Moreover, the authors indicated that planners offered more criteria limited territorially to a city or region than planners with a larger geographical scope.

In the author's report, selected travel planners were evaluated based on the analysis of Internet resources. All previously presented applications supporting travel planning using public transport were analysed and then compared in terms of functionality. The comparative analysis included over twenty different functions – 26 in total. Table 2 lists all the compared functions. The letter "T" marked the application equipped with a given function, and the letter "N" when the application did not have a given function.

Table 2. Summary of available functions in the tested applications/ trip planners

No.	Functions	Jakdojede	Mobile MPK	Moovit	Transportoid	Google Maps	MyBus Online	E-traveller	Kiedyprzyjedzie.pl	Koleo
1	Schedule	T	T	T	T	T	T	T	T	T
2	Map of the entire network of connections of a given mean of transport	T	T	T	T	T	T	T	N	T
3	Possibility to plot a route from point A to B	T	T	T	T	T	T	T	N	T
4	Possibility to set a route from stop to stop	T	T	T	T	T	T	T	N	T
5	Total travel time information	T	T	T	T	T	T	T	N	N
6	Automatic location detection	T	T	T	T	T	T	T	T	T
7	Possibility of using GPS	T	T	T	N	T	N	T	N	N
8	Information about real time of arrival/departure	T	T	N	N	N	T	N	T	N
9	Ability to work offline	T	T	N	T	N	T	N	N	N

Table 2. cont.

No.	Functions	Jakdojede	Mobile MPK	Moovit	Transportoid	Google Maps	MyBus Online	E-traveler	Kiedyprzyjedzie.pl	Koleo
10	Information about integration with various means of public transport	T	T	T	N	T	N	T	N	N
11	Adapted for blind people	N	N	N	N	N	T	N	N	N
12	Possibility to save the route	T	T	T	T	N	T	N	N	N
13	Possibility to purchase a ticket	T	N	N	N	N	N	T	N	T
14	Tutorial module	N	T	N	N	T	N	N	N	T
15	Information about the time of each stage of the journey	T	T	T	T	T	T	T	N	T
16	Possibility to search for connections outside Poland	N	N	T	N	T	N	T	N	T
17	Ability to change language	N	T	N	N	T	N	T	N	N
18	Avoiding selected means of public transport	T	T	T	N	T	N	N	N	N
19	Avoiding selected lines	T	T	N	N	N	N	N	N	N
20	Use of low-floor vehicles only	T	T	N	N	T	T	N	N	N
21	Route without transfers or with a minimum number of transfers	T	T	T	T	T	T	N	N	T
22	Minimum transfer time	T	T	N	N	N	N	N	N	N
23	Distance between transfer points	N	T	T	N	T	N	N	N	N
24	Application availability on Android operating systems	T	T	T	T	T	T	T	T	T
25	Application availability on iOS operating systems	N	T	T	T	T	T	N	T	T
26	Application availability on Windows Phone operating systems	T	T	T	T	T	N	N	T	T
27	Ability to access an external interface API	T	N	T	N	T	N	N	N	T
	SUM of letters (T)	21	23	18	13	20	15	13	6	14

The comparative analysis showed that in terms of functionality, the best rated travel planner is the Mobile MPK application – out of 27 compared functions, Mobile MPK has as many as 23 of them (Fig. 2). The application has timetables for many cities in Poland, the program itself is intuitive and easy to use. Mobile MPK has been equipped with the largest number of route filtering options, greatly impacting the comfort of travelling. Undoubtedly, a big advantage of the program is the ability to work offline, the application automatically downloads timetables for the selected city when it is launched for the first time, so users do not need to connect their mobile phone to the Internet when they launch the application again. In addition, the application has a tutorial module, which allows people who are not proficient in using a phone to handle the travel planner easily. The application's creators pay a lot of attention to improving the program by adding new functions. Another great convenience is the function of the real arrival/departure time of a given means of transport, which is currently one of the most desired options by users.
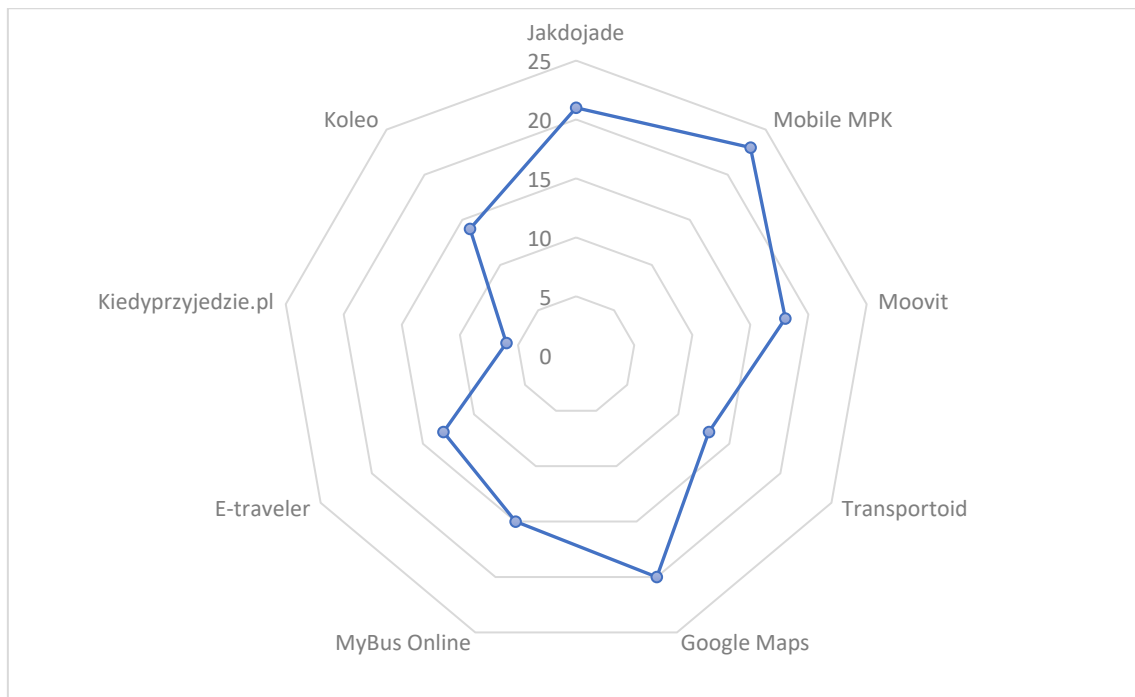
Fig. 2. Planner analysis

The second best-equipped travel planner is the Jakdojade application. Unlike Mobile MPK, Jakdojade has a poorer range of route filtering. The program's main advantage, apart from the real departure/arrival times of means of transport, is the ability to purchase a ticket. Thanks to this function, the user can purchase a ticket online. The lowest-rated application in terms of functionality is Kiedyprzyjedzie.pl. The application has a few of the discussed functions. It works as a virtual information board that displays courses planned 4 hours in advance. The application is available for medium cities, the main and only advantage of which is the real departure/arrival times of means of transport.

4. Requirements for Travel Planners

The final layout of the content and the technical solutions used in the application should make the travel planner user-friendly. It should be constructed so that navigating the application requires the fewest possible full page reloads and the size of the transferred data is minimised. In the case of the connection search engine, it should be ensured that reaching the desired search result by the user requires the fewest possible clicks.

Using the application must be intuitive, i.e., the meaning of the terms used, including descriptions of available options and graphic symbols, should be clear and understandable to the user. At the same time, all steps should be supported by tips and explanations available at the user's request.

The application should be built to present itself similarly in all key browsers and all dominant operating systems. In particular, all versions of the Mozilla Firefox, Internet Explorer, Opera, Chrome, and Safari browsers released in the last 3 years constitute a dominant part of the market. At the same time, the possibility of using the application by users who still use older browsers than the ones mentioned must be guaranteed. In this case, some deviations from the basic way of presenting content are possible, resulting from the older solutions not supporting all currently available standards and technologies. In addition, the application should enable the use of the functionality in text browsers, assuming that options strictly related to graphics, such as using maps, will not be available. The application should also present itself correctly on mobile devices (phones, smartphones, etc.) and their web browsers.

Importantly, the technical solutions of the application cannot lead to the exclusion of disabled people by preventing them from using it. In particular, this applies to the application's accessibility for visually impaired and blind people and people with movement disorders. In particular, ensuring accessibility should be understood as:
- proper structure of the source code with separation of content from appearance,
- proper semantic structure and content hierarchy,
- keyboard navigation availability,
- clear and visible navigation,

– alternative content for graphic files, especially linked ones,
– adapting pages for viewing in high contrast,
– the ability to increase the font size (via browser tools and options built into the service, in both cases maintaining the readability of the Service),
– compatibility of the Service with screen readers, in particular, the ability to quickly navigate to the main content of the Service (skipping menus or navigation, etc.).

It is assumed that the user will be largely freed from the obligation to plan the journey in detail and choose the appropriate ticket rates. The implementation of the system should mean that the passenger can buy a ticket at any time via a mobile application installed on their smartphone or travel by checking in only in the vehicle using a registered medium assigned to an individual account. The system will select the optimal rate for the passenger and charge the appropriate amount of money from the account, guaranteeing the passenger has paid a rate appropriate to their journey.

Analysing the discussed applications in detail, it is postulated that as part of the designed mobile application, the travel planner should at least:

– enable travel planning – using public and non-public means of public transport and individual transport operating in an organised form (metropolitan bike, car sharing and similar systems for other means of transport, systems matching drivers and passengers) and on foot (Dyczkowska et al. 2023),
– provide passengers with information before their journey and update it with information about the actual travel times of the vehicles,
– make a reservation for a seat (for a passenger, bicycle, luggage) in the vehicle,
– inform about the possibility of transporting a bicycle in a given means of transport, inform whether a reservation for a bicycle space is required,
– reserve places for a bicycle on the train,
– cancel the reservation for a bicycle seat on the train,
– check the availability of bicycle spaces,
– provide maps with visualisations of available SRM bikes or other vehicles (ready to rent),
– plan your journey in real time using real timetable data,
– provide the timetable of a given means of transport within the route,
– provide information on the transport of people with reduced mobility and assistance for them,
– integrate with services – reservation/rental/return – Standard mechanism for displaying, reserving, cancelling reservations, renting, returning, settling, and sharing services such as city bikes, car sharing, parking lots,
– check vehicle availability,
– enable vehicle reservation and cancellation,
– provide real-time information about delays in public transport vehicles,
– inform the passenger about a change of track, platform or stop,
– inform the passenger about the cancellation,
– inform the passenger about the route change,
– inform the passenger about the estimated time of arrival,
– inform the passenger about the planned departure time,
– inform the passenger about the reasons for the delay,
– enable browsing a map with the nearest stops marked,
– mark the current stop during the journey on the list of route stops,
– notify Z minutes before leaving for the stop, where Z is the time X needed to get to the stop + time Y defined by the user,
– enable scheduling/planning routes for specific days,
– allow to add places that the planner should avoid,
– enable voice address entry when planning a trip,
– enable changing the start and end locations of the route,
– in the stop/destination search list, it will indicate the city in which the given point is located,
– enable defining a default city whose stops/transport lines, etc., will be positioned higher in search engines,
– enable the passenger to clear their travel history, searches, etc.,
– indicated the starting, intermediate and ending points of the route by dropping a "pin" on the map,
– save and display in the selection list above the X most recently used stops, where X is a system parameter,

- enable the driver to be notified about the need to lower the tailgate in the case of people with mobility disabilities,
- plan a route and save it for later recall without having to re-enter the travel parameters, and allow to delete the travel plan,
- provide information about the means of transport in which the passenger is,
- during the journey, inform the Passenger about the current stop,
- enable editing of a planned route that the passenger has already started,
- enable personalisation of the journey; enable selection of means of transport convenient for passengers in terms of cost, speed of travel, travel comfort, environmental friendliness (Chamier-Gliszczynski 2016a) and present the results on a map in several defined options (e.g. fastest, cheapest, using a bicycle, etc.) and additional personalisation of the journey, e.g. adding a dog to the journey, a bicycle, etc.,
- enable the exclusion of means of transport chosen by the passenger,
- enable checking of available information on the current location of Vehicles,
- enable the use of a mobile device's GPS location by using its current position and automatically setting it as the starting point of the journey,
- present lists of several/dozen or so subsequent departures in addition to the nearest departure to the destination,
- present full and up-to-date timetables (available in the system),
- identify a stop by scanning a QR code or NFC tag,
- enable changing the means of transport to another at nodal points, along with providing the route and time-table for another means of public transport,
- enable the display of messages for the passenger configured by the system operator,
- enable the passenger to select the appropriate stop if they wish to use the stop-to-stop travel option,
- enable the inclusion of timetables of carriers and transport organisers in the system – including those whose tickets cannot be purchased via the application,
- enable the passenger to set the transfer time independently,
- start searching for connections from the current time, if the passenger does not enter the time and date,
- automatically complete names (streets, stops) entered into the travel planner,
- allow users to set an option for the system to save favourite objects,
- provide real-time information about delays,
- enable setting the transfer time or choosing direct connections and travelling with a bike,
- automatically searches for the nearest connections,
- corrected incorrectly entered names (typos, "Czech mistakes", etc.),
- remembers the most recent and most frequently performed routes,
- has the ability to search for pedestrian routes if they are defined in the system,
- plan and enable route planning according to ecological criteria.

To sum up, the planner designed in this way should be simple, understandable, legible, user-friendly and provide full, comprehensive and, above all, up-to-date information. It cannot overwhelm the traveller with too much data. It should provide appropriately segregated and generated information, help make the right choices, and be intuitive. In short, its task is to enable the potential passenger to plan their journey and facilitate selecting the best connection between the source and destination.

5. Summary

Changing climatic conditions, increasing urbanisation, and road traffic mean we need new, more sustainable transport solutions. Fortunately, technology comes to our aid by offering travel planners that not only minimise the negative impact on the natural environment but are also one of the widely used applications that help eliminate the barriers of ignorance and certainty when making decisions (Dyczkowska et al. 2023a) about transport and form of travel. They allow you to prepare for your trip before it even starts. Regardless of where we are going, travel planners are invaluable in providing support when travelling, helping us find the cheapest connections and booking tickets. It is also worth noting that if the travel planner dynamically acquires congestion data (dynamic data on road traffic intensity), the user also minimises time losses. Thanks to modern travel planning applications, getting around the city has become much easier and more enjoyable.

Nowadays, as climate change becomes more and more visible, travel planners are crucial for sustainable travel. They allow you to choose a more ecological means of transport. By choosing a means of transport, we care about the natural environment and contribute to promoting sustainable transport. So, every step towards greener choices contributes to protecting our planet for future generations.

References

Bielański, P. (2016). *Analysis of the use of tools for planning trips by public transport by Internet users.* Diploma thesis, Politechnika Krakowska, Wydział Inżynierii Lądowej. (in Polish)

Bryniarska, Z., Gacek, K. (2018). Using travel planners as a source of passenger information in public transport in Krakow. *Transport miejski i regionalny*, *11*. (in Polish)

Celiński, I., Sierpiński, G., Staniek, M. (2015). *Performing safe movements using a specialized journey planner.* Magazyn Autostrady 5/2015. (in Polish)

Chamier-Gliszczyński, N. (2012). *Modeling system mobility in urban areas*. Congress Proceedings, CLC 2012: Carpathian Logistics Congress, 501-508, 111467.

Chamier-Gliszczynski, N. (2016). *Travelling cost an assessment criterion of the model of city logistics*. Congress Proceedings, CLC 2016: Carpathian Logistics Congress, 287-292, 2017, Zakopane, Poland, Tanger Ltd.

Chamier-Gliszczynski, N. (2016a). *City Logistics – Sustainable Urban Mobility*. CLC 2015: Carpathian Logistics Congress – Conference Proceedings, 263-268, Jesenik, Czech Republic, Tanger Ltd.

Chen, S.J., Mazur, L.M., Sąsiadek, M. (2013). Design task flow optimization and department flow analysis using the design structure matrix and genetic algorithm. *International Journal of Logistics Systems and Management*, *15*(1), 68-92. (in Polish)

Cholewa, M. (2020) *Multi-criteria evaluation of available applications supporting travel planning by public transport in the city. Engineering thesis,* Politechnika Krakowska. (in Polish)

Dinko, A., Jackiva, I., Budilovich, E. (2021). Data sources analysis for sustainable trip planner Development for Riga city. *Transport and Telecommunication*, *22*(3), 321-331.

Dyczkowska, J., Olkiewicz, M., Chamier-Gliczynski, N., Królikowski, T. (2023). Mobility-as-a-Service (MaaS) as a solution platform for the city and the region: case study. *Procedia Computer Science*, *225*, 4092-4100, 196245. https://doi.org/10.1016/j.procs.2023.10.405

Dyczkowska, J., Chamier-Gliczynski, N., Olkiewicz, M., Królikowski, T. (2023a). Decision support in the area of Logistics 4.0. *Procedia Computer Science*, *225*, 4758-4765, 196245. https://doi.org/10.1016/j.procs.2023.10.475

Ejdys, S. (2023). The Transport System of MOF Olsztyn in the Light of Sustainable Development Policy. *Rocznik Ochrona Środowiska*, *23*, 301-311. https://doi.org/10.54740/ros.2023.032

Ejdys, S. (2021). Model of a Sustainable Transport System on the Example of Olsztyn. *Rocznik Ochrona Środowiska*, *23*, 811-822. https://doi.org/10.54740/ros.2021.055

European Commission, Commission staff working document (2014). *Towards a roadmap for delivering EU-wide multimodal travel information, planning, and ticketing services* , SWD(2014) 194 final.

Gacek, K. (2018). *Analysis of the use of travel planners as a source of passenger information in public transport in Krakow. Diploma thesis,* Politechnika Krakowska, Wydział Inżynierii Lądowej. (in Polish)

Jackiva, I., Dinko, A., Budilovich, E. (2023). User-focused Trip Planner with an Expanded Suite of Features: Riga Case Study *Transportation Research Procedia*, 721013-1020.

Jaszkiewicz, A., Szychta, A. (2010). Criteria for evaluating journey planners for public transport. *Transport Miejski i Regionalny*, *05*. (in Polish)

Koźlak, A. (2020). Mobility-as-a Service as progress in transport integration. *Prace Komisji Geografii Komunikacji PTG*, *23*(5). (in Polish)

Ratajczak, A., Zmuda-Trzebiatowski, P. (2017). *Evaluation of the functioning of pedestrian and bicycle trip planners in the Poznań agglomeration.* Prace Naukowe Politechniki Warszawskiej. Transport", 2017, 117. (in Polish)

Solecka, K., Cholewa, M. (2020). Multi-criteria evaluation of applications supporting public transport travel planning in cities. *Transport Miejski i Regionalny*, *06*. (in Polish)

Sierpiński, G., Staniek, M., Celiński, I. (2015). Planning pro-ecological trips using the Green Travelling Planner tool. *Rail Transport Technology*, *22*(12).

Staniuk, W., Staniuk, M., Chamier-Gliszczynski, N., Jacyna, M., Klodawski, M. (2022). Decision-Making under the Risk, Uncertainty and COVID-19 Pandemic Conditions Applying the PL9A Method of Logistics Planning-Case Study. *Energies*, *15*(2), 639. https://doi.org/10.3390/en15020639

Szajna, A., Stryjski, R., Wozniak, W., Chamier-Gliszczynski, N., Królikowski, T. The Management of Digital Data Using Innovative Technologies. *Procedia Computer Science*, *207*, 3143-3152, 184401. https://doi.org/10.1016/j.procs.2022.09.535

Wang, Z., Pel, A., Verma, T., Krishnakumari, P., van Brakel, P., van Oort., N. (2022). Effectiveness of trip planner data in predicting short-term bus ridership. *Transportation Research Part C: Emerging Technologies*, *142*.

Wolański, M., Czerliński, M. (2022). *The role of digitalization in implementing sustainable mobility in Polish cities.* Ekspertyzy i opracowania, 152. Narodowy Instytut Samorządu terytorialnego. (in Polish)

Woźniak, W., Wojnarowski, T. (2015). *The method for a fast selection of the profitable transport offers derived from the freight exchange market*. Proceedings of the 25th International Business Information Management Association Conference – Innovation Vision 2020: From Regional Development Sustainability to Global Economic Growth, IBIMA 2015, 2073-2085.

Woźniak, W., Kielec, R., Sąsiadek, M., Wojnarowski, T. (2018). *A functional analysis of selected transport exchanges and tendering platforms in the transport orders market*. Proceedings of the 31st International Business Information Management Association Conference, IBIMA 2018: Innovation Management and Education Excellence through Vision 2020, 5047-5055.

Zhou, Li J., Zhang, K., Zhang L. (2012). A Multimodal Trip Planning System With Real-Time Traffic and Transit Information. *Journal of Intelligent Transportation Systems*, *16*(2).

https://www.e-podroznik.pl/
http://www.taran.com.pl/mybusonline/
https://www.jelbi.de/
http://transportoid.com/
https://moovitapp.com/
https://www.google.com/maps/
https://www.plany.mobilnosci.pl/materialy/
http://kiedyprzyjedzie.pl/
https://company.jakdojade.pl/o-aplikacji/
https://koleo.pl/
http://www.taran.com.pl/mybusonline/
https://www.mmpk.info/