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Role of Information (Internet) in the Route Choice at Sustainable Urban Public Transport

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The role of information is higher and higher in the modern society. It is the same in transportation, especially in urban environments. An increasing share of the world's population is living in urban environments, and the understanding of transport processes in this field is essential. To be able to produce a better public transport system, the decision-making process of the individual users must be understood. By helping them to make the right decision from the viewpoint of the whole urban society, a more sustainable system can be built up (through a more attractive public transport service, with fewer cars) with highly reduced chemical pollution.
This paper deals with the issue of the helping force of collected information at the special decision of route choice. Five different scenarios will be described to show the power of information in individual decisions. As a basis, there is static information only (like a timetable). In the second case, there are only limited dynamic information sources (real-time user information at the bus stop), while in the third case, the possibilities of permanent dynamic information are considered on the real timetable with the help of IoT. In the final two cases, there is the assumption of a critical mass of IoT in the transportation system, like the passengers' mobile phones and the vehicles themselves. This paper describes a novel theoretical framework. Quantitative and qualitative results are the subject of future work.

1. Introduction

The importance of information is rising nowadays, which means the feeling of being lost without sufficient information. Parallel to these, the "speed" of society is increasing (Colvile, 2016). These tendencies can be seen in the processes of public transport as well. Users want to be informed, want to have precise knowledge of their trips, and want to have exact predictions on the arrival time.
But it was not always the case. This paper gives an overview of the development of information availability during public transport trips and shows the importance of the information. The main goal of the research is to create a general framework which deals with all information types. The next section will show the importance of this novel approach, which covers all main use cases of urban public transport and passenger information in order to make a more attractive service that can facilitate the improvement of the sustainability of transport by increasing the share of public transport and reducing the number of cars.

2. Theory

The theoretical background of the topic is presented by starting with general human decisions followed by decisions in transport, decision models, and literature overview ("state-of-the-art").

2.1 The significance of human decisions

People meet several problems during their lives which can be solved by making decisions. In general, a decision problem can be defined as a perceived need to change (or sustain) a present state in order to achieve (or sustain) a desired state. The state which needs to be changed (or sustained) is called the "problem state", whereas the desired state is called the "target (or solution) state". The problem is solved when the current (experienced) state and the desired state are perceived to be identical by the decision-maker. Problem-solving is the activity of transforming the problem state to the target (solution) state (Paprika, 2002).

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Howard (1968) grouped problems according to complexity, uncertainty (deterministic or probabilistic), and time factor (static or dynamic). Decision problems have some typical aspects, namely, a need is perceived in order to accomplish certain objectives, there are more alternatives, one of which must be selected, and the consequences associated with alternatives are different, uncertain, and not equally valued (Keeney, 1982).
It can be seen that problems are always relative and subjective, as different persons may perceive the same state differently. This implies that the specified problem does not even mean a problem for everyone. Problems can be solved at individual, group, organisational or community level. Problem-solving has four basic steps: discovery, definition (detailed description of the problem), analysis and synthesis (Paprika, 2002).
Decision-making can be influenced by both objective and subjective factors: decision-making is objective as environmental opportunities and limitations are given, and the decision (and its quality) is influenced by the amount of available information. However, it is also subjective as the decision fundamentally depends on the personality, competence and decision-making abilities of the person making the decision. Figure 1 presents the decision-making phases (Simon, 1977).

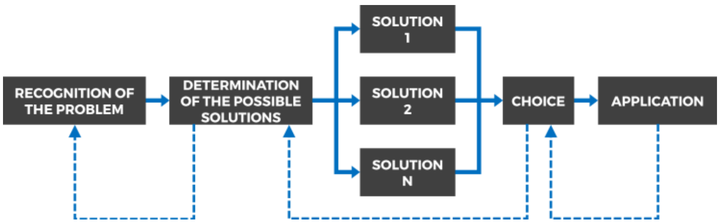

Figure 1: Phases of decision-making

2.2 Decisions in transport

Decisions related to passenger transport can be examined at several levels as well as in several time planes, starting from whether it is necessary to travel at all up to the selection of specific routes (Winkler and Horváth, 2017). The aspects that determine decisions can basically be classified into three groups: characteristics of the travelling person, characteristics of the travel demand (time, motive, occasional or regular travel) and the characteristics of the transport options (cost, travel time, comfort aspects).
The subject of transport decisions can typically be:

- choosing the time and location of the trips;
- choosing the mode of transport (individual or collective means of transport);
- choosing a specified route.

This paper focuses mainly on the last decision type, e.g., the selection of the route (which is also related to the choice of transport mode since different modes may allow the use of different routes).
The importance of route selection depends significantly on the complexity of the transport system: if there is only one route between two points, the question loses its meaning. On the other hand, in the case of a complex network (using either individual or public transport), many options may be available, and the distribution of traffic is basically determined by the decisions that individual travellers make regarding the route. The most important factors in private transport are cost and travel time, while in public transport, these are supplemented by additional, typically comfortable aspects (e.g., number of transfers, waiting times, crowding). Certain routes are closely connected to a specified mode of transport (e.g., only trains run on the railway line. Route 6 is served by "tram no. 6" or “bus no. 6”). Therefore, the issue of mode and route selection also needs to be handled together. Dynamic passenger information tools (on vehicles, at stops, on the Internet, on mobile phones, etc.) also play an important role in route selection (Cats et al., 2011): the availability and accuracy of this information can fundamentally influence the routes chosen by individual travellers (Nökel and Wekeck, 2009).

2.3 Decision models

By using the foundations of decision theory presented above, it is possible to model human decisions. For this, it is necessary to set up appropriate mathematical models and to determine their parameters, primarily the preferences of decision-makers. The first-generation transport models typically aggregated travel needs and decisions, i.e., the basis of the various procedures was the set of traffic districts. Later, disaggregated (also known as discrete or individual) choice models based on individual decisions appeared, the basis of which is the individual or the household. (The individual choice model does not mean that each individual decision-maker is actually differentiated, but groups with certain common characteristics of a given number of people are created. For example, if it is known that 20 % of the analysed trip makers are retired, the decision model reflecting their preferences is applied to this proportion.) The basic idea of discrete choice models is that the probability that a person chooses a specific option is a function of the socio-econometric characteristics of the person and the attractiveness of the given option (Ortúzar and Willumsen, 1990). The main theoretical background of individual decision models is the Random Utility Theory (RUM), which states that individuals who make decisions act rationally and have adequate information, i.e., they always choose the option that maximises their individual utility or minimises their loss of benefit (Louviere et al., 2000). One of the most important elements of these models is the utility function, which specifies the increase in profit (or decrease in profit) for individuals by choosing each option.

2.4 Previous research on the role of information in transport decisions ("state-of-the-art")

The first group of former researchers dealt with the decision-making behaviour of travellers. Wang et al. (2009) studied the role of dynamic information in supporting changes in travel behaviour and travel decisions. The two-stage travel decision process they examined shed light on the links between information technology and travel decision processes. Rodríguez González et al. (2022) constructed a data-driven performance evaluation framework for multi-modal public transport systems based on journeys reconstructed by means of an adapted trip chaining method. Their approach enables the evaluation of the transport system every day, also allowing the extraction of knowledge about passenger behaviour, its evolution and their response to new changes in the network and services. On the other hand, Tomhave and Khani (2022) dealt with a refined choice set generation and the investigation of multi-criteria transit route choice behaviour, as it is very important to be aware of how individuals interact with the transit system. They sampled passenger information from a transit on-board survey containing origin–destination locations, demographic details and trip-specific attributes.

Cats et al. (2011) developed a dynamic transit analysis and evaluation tool that represented timetables, operation strategies, real-time information (RTI), adaptive passenger choices, and traffic dynamics at the network level and was applied to the Metro network area of Stockholm, Sweden, under various operating conditions and information provision scenarios. The results indicated that providing more comprehensive RTI had the potential to lead to path choice shifts and time savings. Sharples et al. (2013) dealt with the topic of journey decision-making as well: they studied the influence of dynamic information presented on variable message signs on drivers. They used two methods: a scenario approach and a medium-fidelity driving simulator. Leng and Corman (2020) examined the role of information availability to passengers in public transport disruptions by applying an agent-based simulation approach. They found that information significantly impacted agents' satisfaction with public transport disruption. Leng and Corman (2022) also studied the impact of incomplete information on passengers by following a Belief-Desire-Intention model. This is able to describe for each passenger their (possibly incorrect, incomplete, non-timely) understanding of network operations. They evaluated route feasibility and passengers' delays in both their beliefs and in reality to understand the effects of incomplete information. Islam et al. (2020) identified that ubiquitous real-time passenger information (URTPI) enhanced the perceived quality of service of public transport as well as enabled travellers to make better pre-trip and on-route travel choices. Based on their results, the most important content of URTPI is the arrival time of buses, whereas there is less interest in the complete journey plans. Furthermore, the importance of different kinds of information is strongly related to the demographics of the travellers.

Wang et al. (2021) studied the effects of providing real-time bus crowding information for passengers. They proposed a novel control policy, namely, providing real-time bus crowding information (BCI) in order to reduce bus bunching and, therefore, prevent longer passenger wait times and uneven distributions of passenger loads, undesirable for both operators and passengers. Their results showed that the bus routes with higher bus loads, frequency or running time variability were suggested to provide real-time BCI. Similarly, Drabicki et al. (2021) dealt with modelling the effects of real-time crowding information in urban public transport systems. Based on their research, RTCI (real-time crowding information) provision can yield total travel utility improvements of 3 % in typical peak hours.

Nielsen et al. (2021) conducted research on the relevance of detailed transfer attributes in large-scale multimodal route choice models for metropolitan public transport passengers. Their results revealed that travellers did consider attributes for transfers, such as ease of wayfinding, presence of shops and escalators at stations, etc., when choosing routes in the public transport network, though real-time information was not included in their list of variables. Durand et al. (2022) examined digital inequality in the context of transport services, as well as its consequences, by examining the impacts of digitalisation in transport services on (potential) travellers. Their research showed that the smartphone had taken a central role, but having a smartphone did not mean that one could derive all of its benefits as being unable or not willing to efficiently operate and use digital technologies in transport services could result in a disadvantage. Fan and Ban (2022) proposed and investigated the concept of a commuting service platform (CSP) to leverage emerging mobility services for commuting and to connect directly commuters and their worksites. The main goal of their research was to present how to develop new CSP-based travel demand management strategies.

The COVID-19 pandemic was also an important sub-topic of this research area. Kanamitsu et al. (2022) dealt with the opportunity of providing information on the congestion of buses on the occasion of COVID-19. Their main aim was to automatically estimate the congestion level on a bus route with acceptable performance, by using Bluetooth low-energy (BLE) signals as sensing data. On the other hand, Ulahannan and Birrell (2022) studied the mode choice preferences following the COVID-19 pandemic. They found that the provision of operationally relevant information to the journey had been only significantly valued by commuters and travellers who could have claimed their journey as a business expense.

Liu and Chow (2022) studied the ways of efficient and stable data-sharing in a public transit oligopoly as a cooperative game. A continuous model was proposed to handle large networks using simulation. Their results showed that perfect information could lead to perfect selfishness, i.e., sharing more data would not necessarily improve transit service for all groups. Ma et al. (2022) proposed a general stochastic ridesharing user equilibrium (SRUE) problem with elastic demand for urban transportation network analysis with ridesharing activities. They showed that if vehicles were equipped with Advanced Traveller Information Systems (ATISs), the travel time and travel demand could be greatly reduced. Mahajan et al. (2022) defined a typology for the data classification based on a set of availability or openness attributes for transport models, as the public availability of data could help in various modelling steps such as trip generation, accessibility, destination choice, route choice and network modelling. Zhou et al. (2022) developed a novel control strategy for mitigating bus bunching by utilising real-time information. Their results showed that providing in-vehicle congestion information could be as effective as the schedule-based and headway-based control methods in achieving mitigation of bus bunching.

Based on the literature review shown above, it can be stated that there is great potential in developing a general framework which deals with all information types. Former researchers have typically dealt with specific cases and sub-problems. Therefore, there is a gap in the general management of the problem.

3. Methods

There is a direct connection between the current research and preliminary research by Winkler (2022). Winkler has proved with real network datasets that the role of information could have an influence on the bus-stop choice. In his studies, he found that users are using stops with real-time information more often than without, even if the stop without real-time information would be more comfortable for them. Based on these phenomena, five cases have been examined on the information supply of the users. In the first case of the traditional information flow (Figure 2a), the users can make their travel choices only before the trip starts, either at home with the timetable or at the stop with the information sheet. Both ways use static information only.

In the second case, users can have additional information at the stops through a real-time passenger information system (Figure 2b), so they are able to modify their trips in the case of unexpected situations (e.g., delays).

In the third case, the passengers are able to use their mobile phones to check the travel situation whenever they want (Figure 3). This is only point-by-point and one-direction information, too.

In the fourth case, there is an information service behind it, with push messages for users who are subscribed to this service (Figure 4a). They have automatic permanent information on the traffic situation of the network.

In the fifth case, there is a permanent duplex information flow (Figure 4b), which means not only the users can have information, but also the users' dataset (position, speed) can be a data source for the information service.

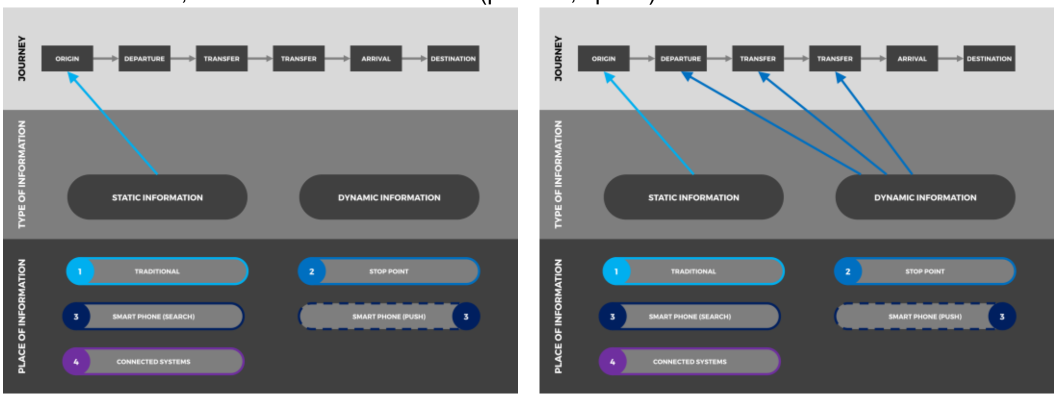

Figure 2: Information supply during public transport trips (2a: static only, 2b: limited dynamic information)

As can be seen, the level of service is different in the different cases. While in the first case, the users are helpless in the case of any unexpected situation, in the fifth case, they can have prompt plans for any situation.

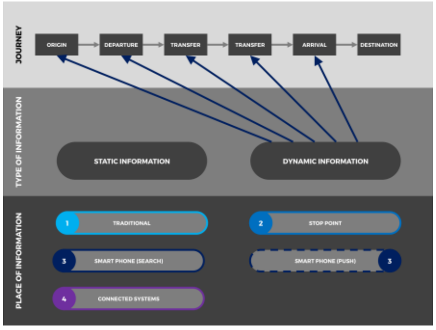

Figure 3: Information supply during public transport trips with full dynamic information availability

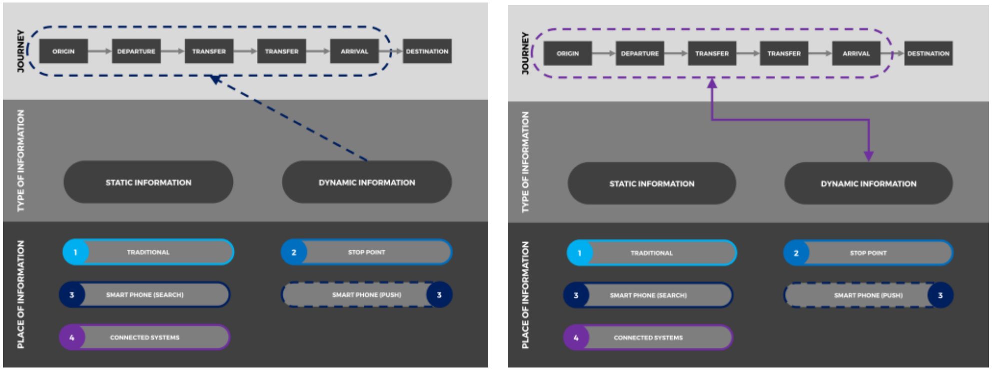

Figure 4: Information supply during public transport trips (4a: push messages, 4b: duplex information flow)

4. Results

The demand for information is rising, so it can be assumed that public transport service providers should not only operate the physical services (e.g., buses) but also an information service. This can facilitate the improvement of the trust and attractiveness of the base service. On the other hand, it cannot be suggested that the whole passenger information is built on mobile phones only. Only 86 % of the population in the EU have subscribed to mobile services. There are 75-80 million persons in the EU who still need traditional stop-related information.
The novel framework presented in this paper covers all important use cases concerning urban public transport and passenger information in order to allow a comprehensive solution.

5. Discussion

Questions of the discussion are as follows. Are there other solutions, or are these the only possible ways? On the other hand, it has been stated there is still a need for traditional information sources parallel to the new and state-of-the-art solutions. Is this right, or the development of society will cancel the traditional information sources in the future? Five different solutions have been presented for informing the users, showing a wide range of solutions. However, many questions are still open and show the direction of future research.

6. Conclusions

It has been shown (in section 3) that there are opportunities to improve the solutions to feed the information hunger of the users. As this paper described a theoretical framework at the current level, quantitative and qualitative results are the subject of future work. It is not sure that the shown solutions are the only possible ways. However, it is a significant result of the research so far that the traditional and/or stop-based information systems are still important and will be important in the near future, too.

References

Cats O., Koutsopoulos H.N., Burghout W., Toledo T., 2011, Effect of Real-Time Transit Information on Dynamic Path Choice of Passengers. Transportation Research Record, 2217, 46–54.

Colvile R., 2016, The Great Acceleration: How the World is Getting Faster, Faster, Bloomsbury, New York, USA.

Drabicki A., Kucharski R., Cats O., Szarata A., 2021, Modelling the effects of real-time crowding information in urban public transport systems. Transportmetrica A: Transport Science, 17, 675–713.

Durand A., Zijlstra T., van Oort N., Hoogendoorn-Lanser S., Hoogendoorn S., 2022, Access denied? Digital inequality in transport services. Transport Reviews, 42, 32–57.

Fan R., Ban X., 2022, Commuting service platform: Concept and analysis. Transportation Research Part B: Methodological, 158, 18–51.

Howard R.A., 1968, The Foundations of Decision Analysis. IEEE Transactions on Systems Science and Cybernetics, 4, 211–219.

Islam F., Fonzone A., MacIver A., Dickinson K., 2020, Use of ubiquitous real-time bus passenger information. IET Intelligent Transport Systems, 14, 139–147.

Kanamitsu Y., Taya E., Tachibana K., Nakamura Y., Matsuda Y., Suwa H., Yasumoto K., 2022, Estimating Congestion in a Fixed-Route Bus by Using BLE Signals. Sensors, 22, 881.

Keeney R.L., 1982, Decision Analysis: An Overview. Operations Research, 30, 803–838.

Leng N., Corman F., 2020, The role of information availability to passengers in public transport disruptions: An agent-based simulation approach. Transportation Research Part A: Policy and Practice, 133, 214–236.

Leng N., Corman F., 2022, Communicating delays and adjusted disposition timetables: Modelling and evaluating the impact of incomplete information to passengers. Expert Systems with Applications, 191, 116265.

Liu Q., Chow J.Y.J., 2022, Efficient and stable data-sharing in a public transit oligopoly as a competitive game. Transportation Research Part B: Methodological, 163, 64–87.

Louviere J.J., Hensher D.A., Swait J.D., 2000, Stated Choice Methods – Analysis and Applications. Cambridge University Press, Cambridge, UK.

Ma J., Meng Q., Cheng L., Liu Z., 2022, General stochastic ridesharing user equilibrium problem with elastic demand. Transportation Research Part B: Methodological, 162, 162–194.

Mahajan V., Kuehnel N., Intzevidou A., Cantelmo G., Moeckel R., Antoniou C., 2022, Data to the people: a review of public and proprietary data for transport models. Transport Reviews, 42, 415–440.

Nielsen O.A., Eltved M., Anderson M.K., Prato C.G., 2021, Relevance of detailed transfer attributes in large-scale multimodal route choice models for metropolitan public transport passengers. Transportation Research Part A: Policy and Practice, 147, 76–92.

Nökel K., Wekeck S., 2009, Boarding and Alighting in Frequency-Based Transit Assignment. Transportation Research Record, 2111, 60–67.

Ortúzar J., Willumsen L., 1990, Modelling Transport. John Wiley & Sons, Chichester, UK.

Paprika Z.Z., 2002, Decision Theory. Alinea, Budapest, Hungary. (in Hungarian)

Rodríguez González A.B., Vinagre Díaz J.J., Wilby M.R., Pozo R.F., 2022, Data-driven performance evaluation framework for multi-modal public transport systems. Sensors, 22, 17.

Sharples S., Shalloe S., Burnett G., Crundall D., 2013, Journey decision making: The influence of dynamic information presented on variable message signs. ECCE '13: Proceedings of the 31st European Conference on Cognitive Ergonomics, August 2013, 27, DOI: 10.1145/2501907.2501958.

Simon H.A., 1977, The New Science of Management Decision, Prentice Hall, Englewood Cliffs, USA.

Tomhave B., Khani A., 2022, Refined choice set generation and the investigation of multi-criteria transit route choice behavior. Transportation Research Part A: Policy and Practice, 155, 484–500. (in Hungarian)

Ulahannan A., Birrell S., 2022, Designing Better Public Transport: Understanding Mode Choice Preferences Following the COVID-19 Pandemic. Sustainability, 14, 5952.

Wang P., Chen X., Zheng Y., Cheng L., Wang Y., Lei D., 2021, Providing real-time bus crowding information for passengers: A novel policy to promote high-frequency transit performance. Transportation Research Part A: Policy and Practice, 148, 316–329.

Wang X., Khattak A.J., Fan Y., 2009, Role of dynamic information in supporting changes in travel behavior: Two-stage process of travel decision. Transportation Research Record, 2138, 85–93.

Winkler Á., 2022, Effect of dynamic passenger information displays on the proportion of stop usage, XX European Transport Congress / XII International Conference on Transport Sciences, Győr, Hungary, 72–79, <https://www.researchgate.net/publication/361560414_Effect_of_dynamic_passenger_information_displays_on_the_proportion_of_stop_usage>, accessed 02.11.2023.

Winkler Á., Horváth B., 2017, Intelligent Decision Support Technologies in Public and Individual Transport. Intelligent Decision Technologies, 11, 441–449.

Zhou C., Tian Q., Wang D.Z.W., 2022, A novel control strategy in mitigating bus bunching: Utilizing real-time information. Transport Policy, 123, 1–13.