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Information for Urban Intermodal Transport: Brief Literature Review

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Abstract
This paper presents a limited literature review of information for urban intermodal transportation. A systematically approach of the published literature on the area has been done, with particular focus on urban passenger intermodal terminals and public transport real-time information. The information obtained was collected and compiled by the following themes: i) Public Transport Information; ii) Urban Transport Interchanges; iii) Intermodal Transfer Services. This work highlights some important literature gaps and shows that, in this domain, there are several open interesting research opportunities.

Subject Headings. Urban Transport, Public Transport, Combined Transport, Transport User, Information User, Information System, Intelligent Transport System
Author Keywords. Real-Time Information, Passenger Intermodal Terminals, Hubs, Multimodal Journey

1. Introduction

The trend towards urban sprawl in European cities has led to significant changes in mobility patterns. Nowadays, intermodal transport is an integral part of the sustainable mobility and its enhancement is of vital importance particularly in high congested urban areas. However, there are few opportunities for direct journeys when opting to use public transport and most trips require a transfer. Therefore, urban transport interchanges play a key role in public transport networks.

To facilitate multimodal journey, many complex urban transport interchanges have been established. For example, many train stations have been developed as multimodal interchange nodes.

Intelligent Transportation Systems (ITS) include the use of information and communication technologies (ICT) in innovative services for all modes of transport - road, rail, water and air transport. In urban transportation networks, ITS have been used from many decades for various purposes including, more recently, automatic vehicle location and real-time passenger information (Adler and Blue 1998). ITS enable users to be better informed and make smarter use of transport networks. From the users (passengers) point of view, provision of information is definitely the most important service ITS can offer.

The purpose of this paper is to analyse and condense, in a systematically approach, some of the most relevant published literature on the area with particular focus on urban passenger intermodal terminals and public transport real-time information.

A limited review of literature was conducted (using the Scholar Google database) and initially only articles in English published in the last five years (2012 to 2016) were selected.

Under these constraints, the first pre-selection of papers was made by title and keywords, and from this first list of selected articles, a second smaller selection was made after reading through the abstracts.

From the existing references in some of the articles that were being read, new articles were selected (including articles prior to 2012).

With the review, and for each analysed paper, a short summary was written, highlighting the main differentiation aspects of the works and its key contribution.

2. Brief Review Literature

Approximately 20 articles were selected. All information regarding the subject in hand was collected and compiled by the following themes: i) Public Transport Information; ii) Urban Transport Interchanges; iii) Intermodal Transfer Services.

2.1. Public Transport Information

Public Transport Information can refer to service schedules, fares or transfers as well as real-time situations such as bus/tram/metro arrival/departure time, service disruptions and other related events.

Molin and Timmermans 2006 presented a study that reports the relative importance travellers attach to a range of information aspects. In addition, the willingness to pay for this information was examined by conducting a stated choice experiment, in which price was traded off against groupings of information aspects. The results of the study showed that even though public transport travel information is highly price sensitive, travellers were willing to pay for it if the information systems provide additional functionality, such as real-time information and additional trip planning options.

The following table presents the average importance score for each of the empirically defined information attributes. Real-time information was considered by far the most important attribute.

	Mean importance score
Real time	4.8
Planning options	3.9
Tickets	3.8
Walking route	3.8
Interchange: functional requirements	3.7
Private transport	3.3
Comfort and service	3.3
Interchange: activities	3.0
Destination	2.8

Table 1: Importance of information attributes (Molin and Timmermans, 2006)

Hannikainen, et al. 2001 presented a Passenger Information System (PIS) called TUTPIS which has been developed in the Institute of Digital and Computer Systems at Tampere University of Technology (TUT). TUTPIS is an information system that networks passengers with companies that provide public transport services. TUTPIS supports a passenger with personalised real-time information services in all phases of a journey. Services included timetables, travel route searching, route reservations and electronic payment. The design and implementation of personalised passenger information services have been researched in the TUTPIS project. The system utilises wireless access networks for delivering the services.

The designed TUTPIS service architecture model with various network technologies is illustrated in the following figure.

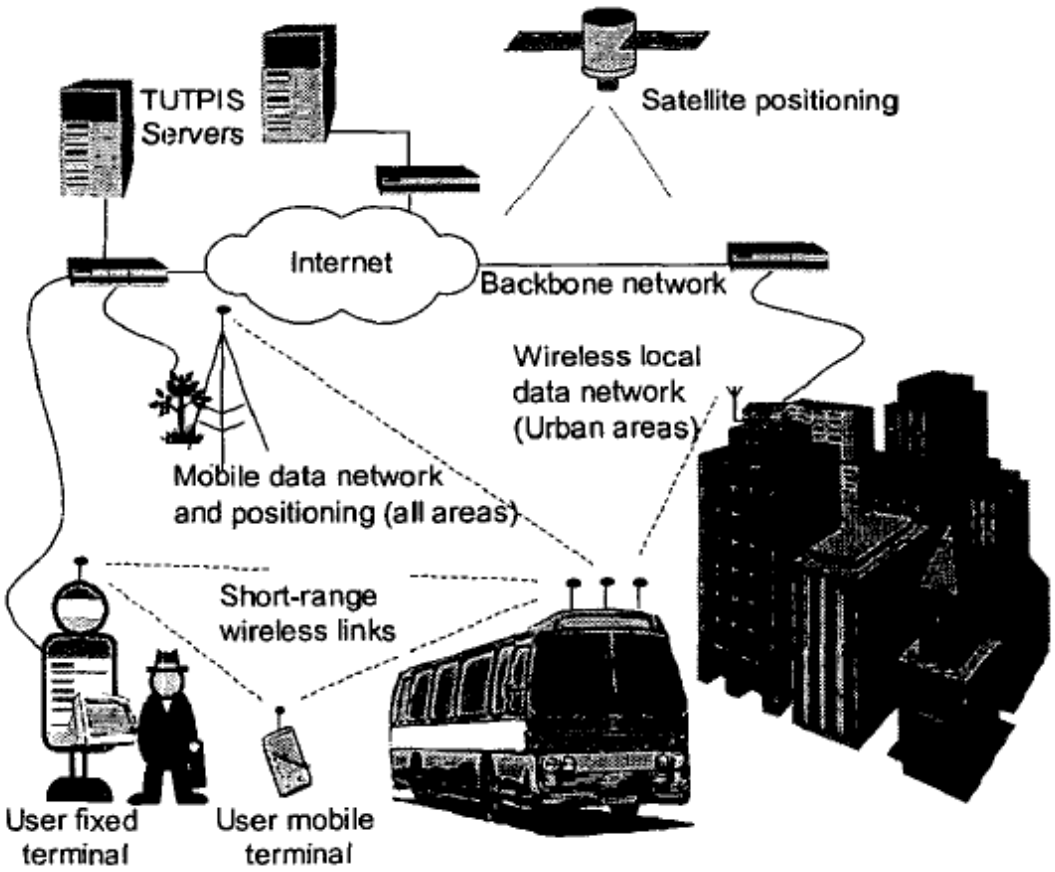

Figure 1: TUTPIS service architecture for bus passengers (Hannikainen et al., 2001)

Caulfield and O'Mahony 2007 focused on the provision of public transport information in Dublin, Ireland. Several methods of accessing information, were examined, with particular focus on the implementation of various intelligent transport systems applications. A web-based survey was used to collect data on passenger preferences and describes the methods of information delivery each passenger requires at each stage. Information provision formats comprise call centers, mobile phones, the Internet, and paper-based methods.

Zografos, et al. 2009 presented the design and evaluation of a passenger information system with multimodal trip planning and travel information services. The proposed system, called ENOSIS, provides multimodal trip planning services and real-time travel information throughout the entire life cycle of an urban or interurban trip. The real-time travel information delivered by ENOSIS refers to reminders regarding regular travel-related events (e.g., departure time reminder) and any unexpected event that disrupts the travellers' trip (e.g., change of departure time). An integrated methodological framework was developed, involving three system-assessment categories: 1) technical performance adequacy; 2) user acceptance; and 3) socioeconomic impacts. A pilot (prototype) of the proposed system has been developed covering long-distance trips in Greece and urban trips in the City of Athens, and the evaluation results of the ENOSIS pilot application were reported. Two groups of experts were involved in the ENOSIS cost-effectiveness study: 1) experts on passenger information systems from the Department of Information Technology and Telecommunications of Athens International Airport (AIA) and 2) experts on port operations from the Heraklion Port Authority. The results from the analysis for both groups indicated that the ENOSIS system was cost-effective as compared with the corresponding existing passenger information systems in both terminals.

Politis, et al. 2010 presented an evaluation, from the users' point of view, of a Bus Real Time Passenger Information (RTPI) system, installed at the city of Thessaloniki, Greece. The analysis performed on the data collected from the survey (300 questionnaires were returned) shows that the existing RTPI system is generally evaluated positively (satisfaction levels were over 80% for both the content and the reliability of the information given). An important finding was that public transport users highly value real time information services, as was also referred in Molin & Timmermans, 2006.

García, et al. 2012 described a traveller assistant for public transport. The system provides public transport information to on route passengers, using existing infrastructures at stops and stations. Passengers use their communications devices (for example mobile phones) to access the information provided by the public transport network infrastructure.

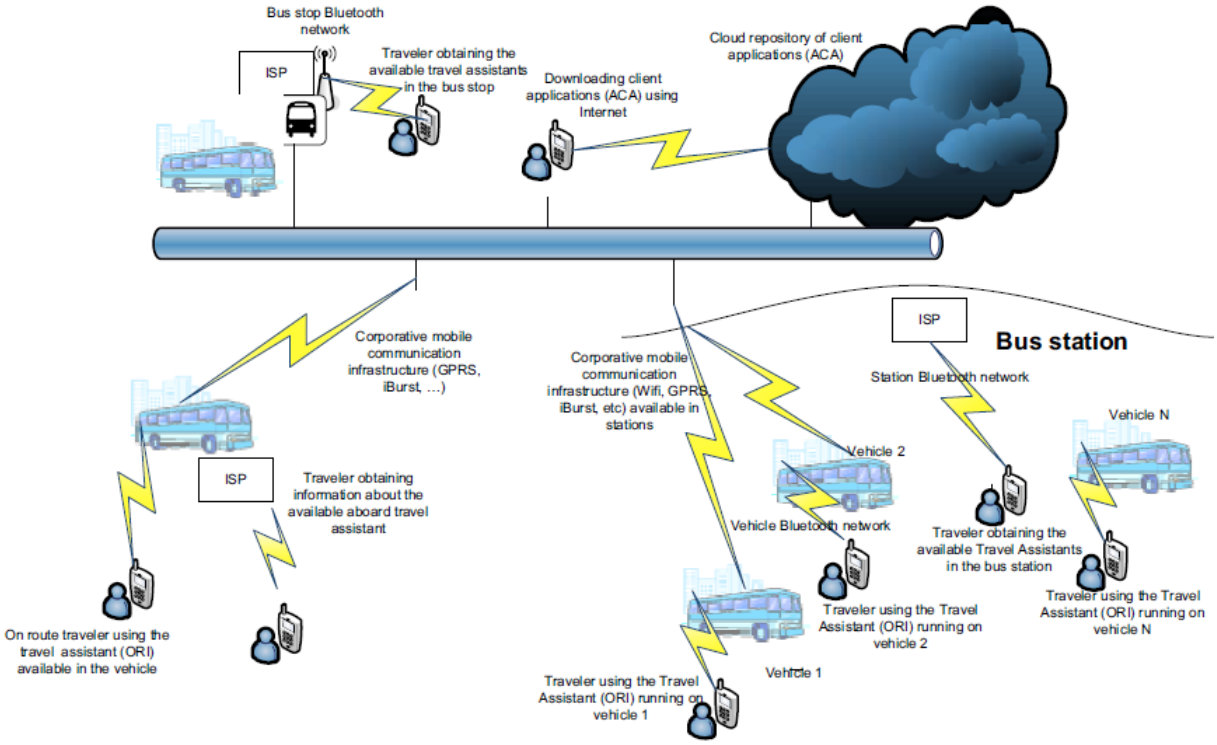

Figure 2: General vision of the system (García et al., 2012)

The main purpose of this system was to provide real time information about the route (for example, estimated time to the next stop or to the traveller destination) and tourist information about nearby interesting points.

Monzon, et al. 2013 provided an assessment methodology which evaluates how Real Time Passenger Information (RTPI) systems improve the quality of bus services performance in two European cities: Madrid and Bremerhaven. The research results have indicated the importance of providing high quality bus services. For this purpose, the use of RTPI systems appear to be a key factor. In both case studies, the surveyed passengers showed a higher perceived quality of service when stops and buses are equipped with information devices.

2.2. Urban Transport Interchanges

Travel patterns in urban areas are becoming increasingly complex, and many public transport users need to transfer between different modes to complete their daily trips. Urban passenger intermodal terminals are the transport network nodes and their main objective is the efficient transfer of passengers between various routes and different modes of transport.

Pitsiava-Latinopoulou and Iordanopoulos 2012 investigated how the provided level of service of passenger intermodal facilities affects the commuters' behaviour regarding the modal choice. A categorization of the various terminals was attempted, considering their specific characteristics in terms of the means that they serve as well as the commuters that use them. A case study was executed based on a Revealed Preference Survey for the Intermodal Terminals of the city of Athens, in order to examine the impact of their operation on the number of interchanges between the various transport modes. The case study used data obtained by a study on urban public transport which was conducted by the Athens Urban Transport Organization in 2006. It aimed to investigate the mode used by public transport passengers in order to approach the terminal area (including all modes i.e. private car, taxi, foot). The questionnaires were conducted at 32 key transit areas of Athens city and referred to 39.110 travellers boarding the public transport systems serving the terminal area. The study showed some interesting aspects, such as: the effectiveness of a terminal in terms of intermodality is not only subject to the number of public transport modes serving it but also to the provided level of connectivity, which was found to be highly related with the spatial location of each mode's platforms and the synchronization of their services.

Dell'Asin, et al. 2014 identified key quality factors at urban interchanges through an exploratory approach. The methodology was applied at interchanges in Madrid and Gothenburg and the data used in the analysis were collected through customer satisfaction surveys conducted in 2011. The analysis identified five key quality factors per interchange: Physical (space at the station, total seating capacity and ventilation within the interchange); Technology (availability to reschedule tickets and internet access); Comfort (physical and environmental aspects, with a strong association to toilet availability); Ticketing (possibility of buying different types of tickets either at ticketing machines or from staff at counters, personnel service and the possibility of rescheduling tickets); Wellbeing (cleanliness of the entire terminal and ventilation).

Hernandez, et al. 2015 proposed a methodological framework to identify the potential strengths and weaknesses of urban transport interchanges from the users' point of view. A travellers' survey was carried out in the Moncloa transport interchange (Madrid, Spain) and the framework was applied to the data collected. The study concluded that the greatest strengths of the interchange from the users' point of view are the information provision through signposting, the features of the internal design of the interchange, and security conditions, particularly during day-time.

Hernandez and Monzon 2016 carried out an ad-hoc travellers' satisfaction survey in three European transport interchanges. The research has identified the key factors from the users' point of view that define an efficient transport interchange.

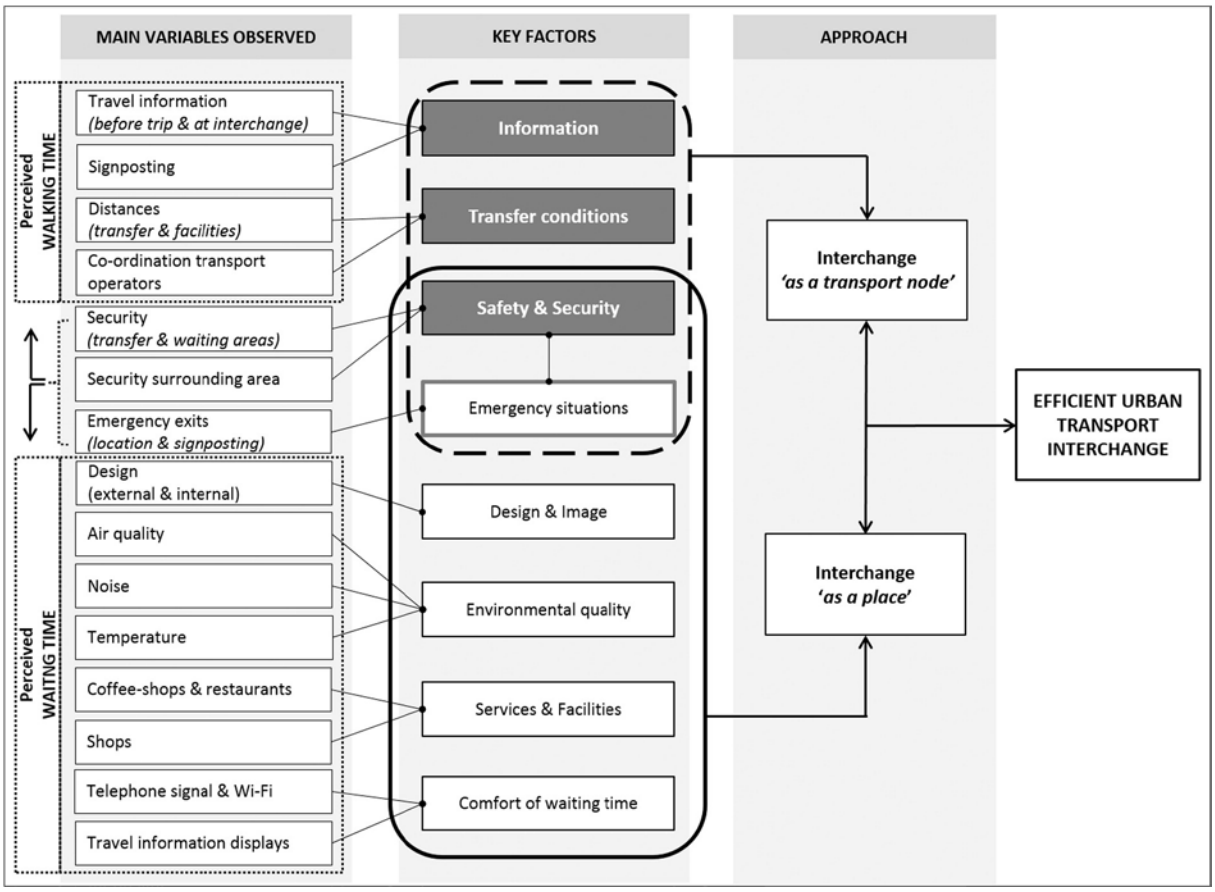

Figure 3: Key factors in a transport interchange (Hernandez & Monzon, 2016)

It was concluded that an urban transport interchange can host other type of activities and so should be conceived both as 'a transport node' and 'a place'.

Harmer, et al. 2014 presented findings from the first stages of the City-HUB project (a European Commission 7th framework programme research project), which have identified the numerous factors that need to be combined to make a successful interchange. The methods used include literature reviews, practitioner interviews (with transport operators, local transport authorities and the business community involved in planning, designing and operating successful interchanges) and traveller surveys (of passengers at interchanges across Europe).

Monzón, et al. 2016 concluded that an urban transport interchange should organize the space among three different zones: access-egress zone; facilities zone; and arrival-departure-transfer zone. Based on the research done in the City-HUB project, a vision of interchanges is presented.

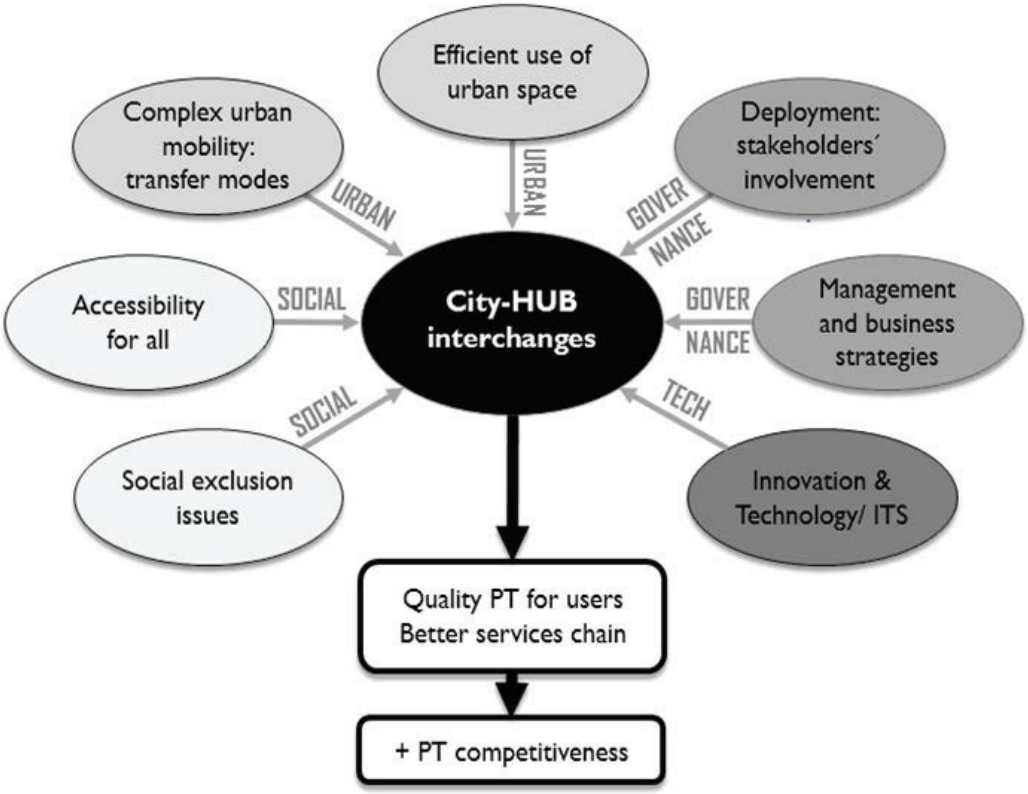

Figure 4: City-HUB vision of interchanges (Monzón, et al. 2016)

2.3. Intermodal Transfer Services

Passengers are usually compelled to choose different transportation modes during one trip. Thereby it is crucial to keep the traveller up-to-date with real-time information during the journey. The amount of incoming data in intermodal route planning services is growing consistently and the answer to unexpected events has to be made in real-time.

Zografos, et al. 2010 identified the travellers' information requirements that should be used for designing a passenger information and multimodal journey planning system covering international journeys. A methodological framework was developed and the data needed were collected through a travellers' survey covering five European countries and China. A set of information services was identified to cover traveller's information needs. According to the results of the data analysis, door to door journey planning customised to the special needs of the traveller and real-time personalised alerts (through the mobile phone) constitute the types of information services considered most important from the travellers perspective. Figure 5 presents the overall scores calculated for the traveller's information services through the application of the Quality Function Deployment (QFD) method. It could also be verified from Figure 5 that the access to personal information through the internet and the mobile phone is preferred to info kiosks and PDAs.

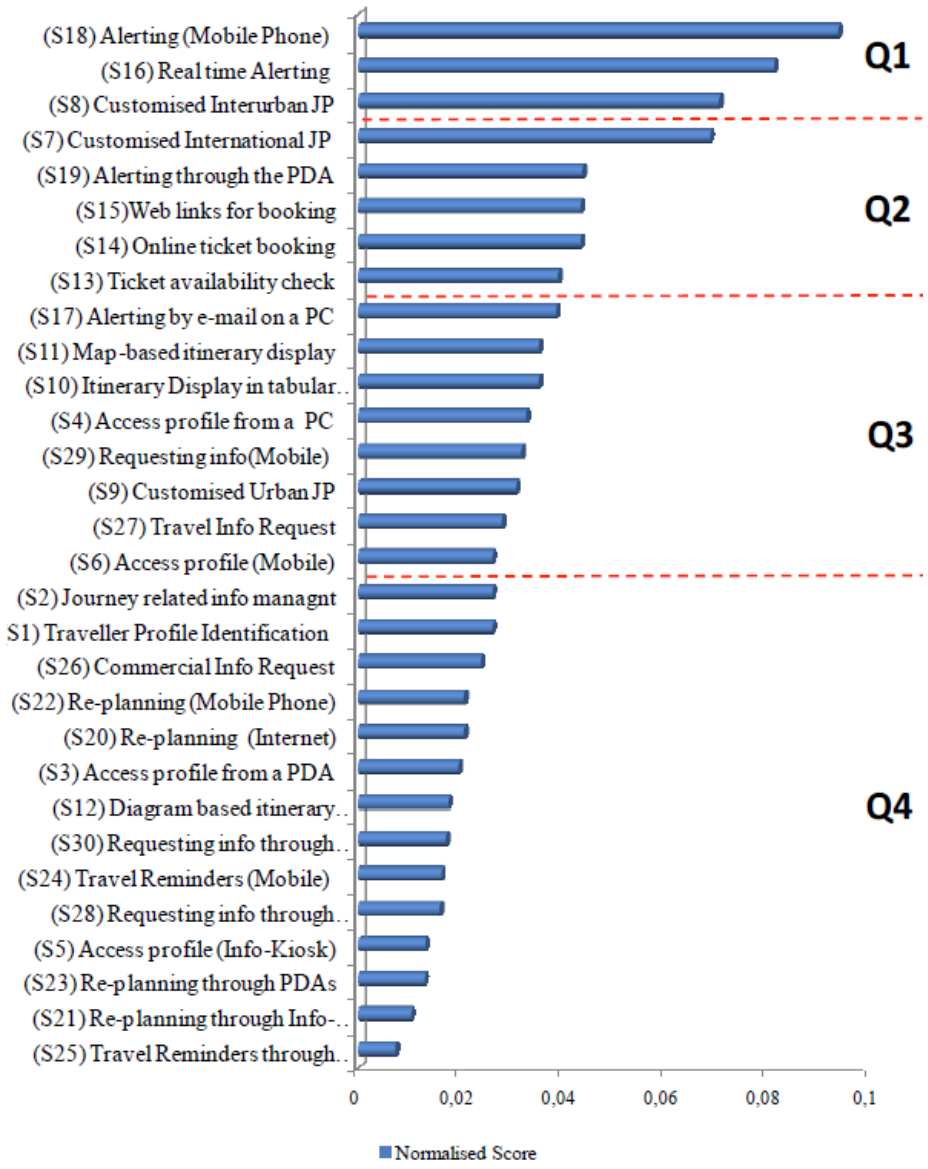

Figure 5: Ranking of the types of information services to international travellers (Zografos, et al. 2010)

Li 2013 studied current practices of traveller information services for multimodal interchanges and concluded that passenger experience in an interchange is often related to travel information available on the interchange (e.g. guidance at interchanges, real departure times of next transport modes, walking distance to next transport). The study referred that walking distance and travel time inside an interchange are often missing or ignored by multimodal journey planners. The paper also gives recommendations on needs of traveller information for interchanges.

Birth, et al. 2015 proposed a conceptual architecture model for a real-time intermodal route guide to assist travellers on their journey by providing information in real-time and reacting to unexpected events. An Android prototype (see figure 6) based on this architecture was developed and tested in Munich.

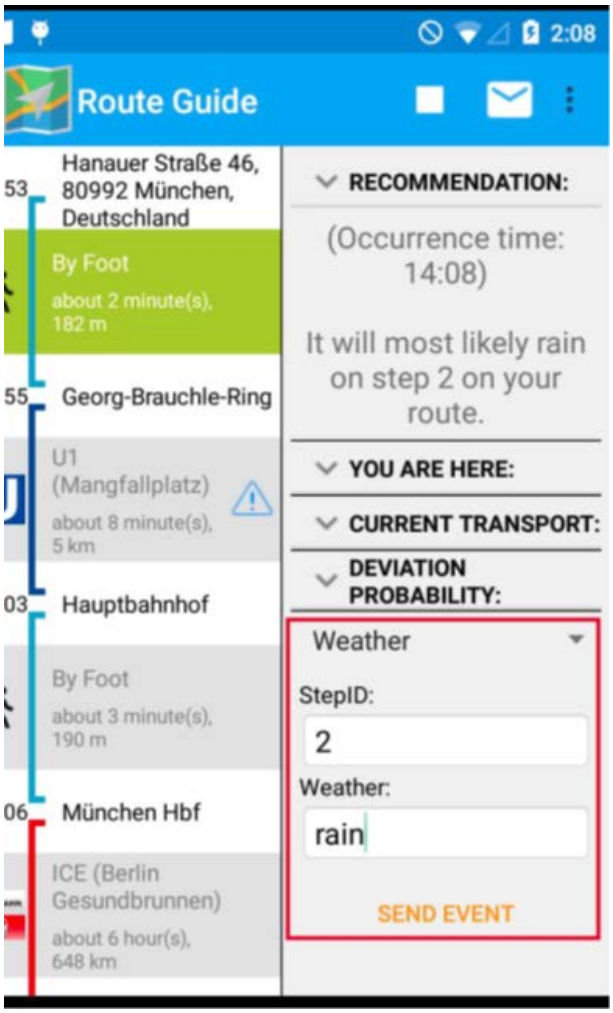

Figure 6: Screenshot of the Android prototype (Birth, et al. 2015)

3. Conclusion

One of the main problems in urban areas is the steady growth in car ownership and traffic levels. Therefore, the challenge of sustainability is focused on a shift from private cars to collective means of transport.

Passengers has a better opinion of the public transport when stops and buses are equipped with information devices and Monzon, et al. 2013 also showed that Real Time Passenger Information (RTPI) is considered an important factor to provide high quality bus service. So, good RTPI systems could help people to change their travel behaviour towards more sustainable transport modes, by reducing car use.

The technologies used in RTPI systems (websites, smartphone applications, etc.) have been developed quite rapidly and there are hundreds of similar applications all over the world.

Information services on urban transport interchanges (which can be provided by the operators of interchanges or a third party) include displays, kiosks and indoor maps. However, while the general facilities of multimodal journeys are ready, there is still lack of comprehensive information on urban transport interchanges. In other words, interchanges often become a 'blank point' of the traveller information chain (Li 2013).

Real-time information is needed to guide a traveller through a complex interchange, however a question remains: Which is the better way to obtain and disseminate this information?

Travel times within the interchanges should be taken into account when planning the next connections, but how to obtain this necessary data and include it in multimodal journey planners?

Regardless the limited review of literature that was done, the above questions seem to be gaps and opportunities of research. Namely, in the crossing between Real-Time Passenger Information and Urban Transport Interchanges several open interesting research opportunities seem to exist.

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