Abstract.
We present an advanced journey planner designed to help travellers to take full advantage of the increasingly rich, and consequently more complex offering of mobility services available in modern cities. In contrast to existing systems, our journey planner is capable of planning with the full spectrum of mobility services; combining individual and collective, fixed-schedule as well as on-demand modes of transport, while taking into account individual user preferences and the availability of transport services. Furthermore, the planner is able to personalize journey planning for each individual user by employing a recommendation engine that builds a contextual model of the user from the observation of user’s past travel choices. The planner has been deployed in four large European cities and positively evaluated by hundreds of users in field trials.

1 Introduction

The advent of new types of mobility services, such as bike, electric scooter or car sharing, real-time carpooling or next-generation taxi, has further expanded the already rich portfolio of means of travel available in modern cities. Providing intelligent tools that would help citizens make the best use of the mobility services on offer is thus needed more than ever.

Despite recent algorithmic advances [1], existing planners available in practise, such as Google Maps [5] or Here.com [6], address this need only partially. In particular, they only consider a limited subset of transport modes and their combinations, and they only provide limited ways for users to express their travel preferences.

Employing a generalized planning problem representation [4] and recommendation techniques [3], we have developed and deployed a journey planner that overcomes these limitations and provides a fully multimodal, contextually personalized journey planning capability.

2 System Description

The architecture of the planner follows standard system architecture patterns and comprises of the data, business logic and presentation layers (see Figure 1). The components of the data and business logic layers are deployed primarily on the backend server while the presentation layer components run primarily in a client’s web browser. Below we describe the main components in a more detail.

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on top of generalised time-dependent graphs. The generalised time-
dependent graph [4] is a recently proposed data structure that en-
codes the information about all transport modes in a single planning
graph, thus enabling fully multimodal journey planning.

To promote modularity and extensibility, the planner employs a
novel multi-critics architecture that relies on the notion of critics,
specialized modules for evaluating candidate journey plans from a
certain perspective, e.g., price, emissions or user convenience. The
multi-critics architecture allows introducing new concerns and/or ob-
jectives to journey planning without modifying the core planning
logic. At the moment, the planner considers distance, duration, CO₂
emissions, physical effort and user satisfaction in journey planning.

2.3 Recommender Engine

The personalization of journey plans is implemented through the rec-
ommendation module. By observing past users’ travel choices and their
situational context, the recommender learns a model of the user and
leverages this model to provide tailored journey plans reflecting the
unique preferences of each user. The recommender employs latest
developments in context-aware recommendation [3] as well as col-
laborative filtering algorithms to enhance journey plans with points of
interest that might be relevant to the user. Technically, recommend-
ation is integrated with journey planning through a critic that pro-
vides user satisfaction scores for different candidate journey plans.

A number of journey features are used for building the user model,
including journey elevation, duration, distance, transport mode, cost
and physical effort exerted. Furthermore, situational context at-
tributes concerning the city (i.e., weather, illumination, pollution and
time of the day) as well as the user perspective (i.e., purpose of jour-
ney and companionship) are reflected in journey recommendations.

2.4 Mobility Resource Negotiator

The planner supports the full range of transport modes, including ser-
dvices with limited capacity, such as parking, or those that need to be
arranged on request, such as taxis or car sharing. To facilitate the use
of such services the planner employs a mobility resource negotia-
tor component. The mobility negotiator interacts with the transport
service providers on behalf of the user and allows selecting and re-
serving services that best match the requirements of the journey plan
under consideration. Similarly to the recommender, the resource ne-
gotiator is integrated with journey planning through a resource critic,
which provides the planner with the feedback on the expected avail-
ability and price of requested mobility resources and which can au-
tomatically reserve the resources if authorized to do so by the user.

2.5 Web-based Frontend

The demonstration version of the planning system includes a sim-
plified web-based frontend which allows users to submit journey
planning requests and interactively explore recommended journey
plans (see Figure 2). More feature-rich frontends, both web- and
smartphone-based, are available as part of the full SUPERHUB soft-
ware platform [2]. The frontend is integrated with the planner back-
end through a web services API. This allows additional, third party
applications and services to be developed on top of the planner.

Figure 2. Web-based frontend for the planner. A set of fully multimodal
journey plans returned by the planner for the city of Milan is shown together
with the values of six supported journey criteria for each plan.

3 Real-World Deployment and Evaluation

We deployed the presented planner, along with additional compo-
ents, as part of the SUPERHUB project’s field trials in three large
European cities (Barcelona, Helsinki, and Milan). Several hundred
trial participants used the planner for a period of three weeks. The
feedback was largely positive – the users commended the quality of
plans and the responsiveness of the system, which was able to return
plans within one second in most circumstances.

As part of the evaluation process, we compared our planner with
the Google Maps multimodal journey planner provided through
Google Directions API [10]. Despite having a broader set of features,
our planner provided comparable or better journey plans when com-
pared in terms of journey duration and the number of transfers.

We currently work on a significantly extended version of the plan-
ner supporting planning with real-time traffic and transport data,
automated on-trip replanning and improved booking and reserva-
tion. The latest version of the planner is accessible on-line from
http://agents4its.net.

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REFERENCES

[1] H. Bast, D. Delling, A. Goldberg, M. Muller-Hannemann, T. Pajor,
P. Sanders, D. Wagner, and R. Werneck, ‘Route Planning in Transporta-
and S. Marzorati, ‘SUPERHUB: A user-centric perspective on sustain-
able urban mobility’, in 6th ACM workshop on Next generation mobile
computing for dynamic personalised travel planning, pp. 9–10. ACM,
(2012).
[3] V. Codina, F. Ricci, and L. Ceccaroni, ‘Local context modeling with se-
matic pre-filtering’, in 7th ACM conference on Recommender systems,
multimodal journey planning’, in 16th International IEEE Conference