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Incorporating Systems Engineering Methodologies to Increase the Transferability of Journey Planners

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Abstract

One characteristic that is highly desired in transportation-related applications, and particularly journey planners, is transferability – i.e., the capacity to be used with minimal modification in different locations. To achieve transferability, the initial design must take into account all factors that may diverge between locations, including existing modes of transport, the availability of required data, the technological habits of users, etc. In consequence, a highly transferable system is difficult and expensive to develop and maintain. A very flexible initial design, one ensuring low-cost adaptability of the system for different cities, regions, or countries, might not be cost-effective. On the other hand, a rigid design, tailored for a specific location, might act as a barrier to implementing the system elsewhere. This dilemma has motivated researchers to seek a structured process for selecting the most promising design, one that will realize the benefits of transferability while minimizing development costs.

One of the fundamental building blocks of structured design in SE is requirements-design exploration. This paper evaluates the use of Multi-Attribute Tradespace Exploration (MATE), a leading design exploration process, for the effective design of journey planners.

We examine the process of changeability assessment (e.g., transferability) in light of the goals of journey planning from the point of view of different stakeholders: travelers, private developers, and transport authorities. The analysis demonstrates how tradespace exploration can also be used to identify specific designs that bridge the gap between the public and private sectors and provide value over time to all parties. Moreover, when specific concerns of public authorities are not met, tradespace exploration can reveal measures the public sector can take (financial or others) for making their preferred design attractive to the private sector as well.

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1. Introduction

Journey Planners (JPs) have become a part of mobility services that almost every traveler expects to have. A multimodal journey planner is an IT system able to propose a set of one or more transport services answering at least the question "How can I go from location A to location B at a given departure/arrival date and time and under which conditions, using various modals" (ITS Action Plan 2011). Modern JPs support multiple user objectives while accounting for his/her constraints and available resources (Bie et. al, 2012). Future JPs are expected to actively influence user behavior by introducing incentives as well as travel information.

JPs are often sponsored, fully or partially, by transportation authorities, which understand their potential to promote the use of sustainable modes of transport, such as public transportation (PT), cycling, walking, or ridesharing. Moreover, JPs can support economic and tourism development in a region by increasing mobility and social inclusion and opening opportunities for private services and revenue-generating activity.

From the perspective of public authorities, such initiatives raise three interrelated questions:

- What features of a JP will enable it to be transferable to different locations (e.g., cities or regions)?
- What features of a JP will ensure a business model able to minimize public funding over time?
- What investment of public funding will be needed to achieve the benefits of a JP as an ongoing promoter of sustainable transport in a variety of locations?

Clearly, design of a JP must take into account the needs of the travelers who are its potential users, as well as the concerns of its developer. The goal of this paper is to propose a systematic approach for analyzing various possible designs and selecting the most promising ones, based on methodologies adapted from the domain of SE. Our purpose is to demonstrate how these methodologies can be applied to the design of a JP, while aiming to ensure that the needs of all stakeholders are addressed.

2. The problem of transferability

Most JPs are initially developed in a narrow context, Yet both private developers and public authorities have an interest in ensuring that the JP can be used in different contexts, whether in a different geographical context, or by a different group of people – a trait known as transferability. However, achieving transferability is not simple, as different locations and users groups have their own demands and constraints. For example, a JP developed for a region where raw data (maps, transit routes etc.) is available online as data feeds will need alteration for a region where such data must be manually updated.

These issues present a design problem for all parties engaged in the development process. Specifically, should transferability be considered in the initial design, and if so, to what extent and under what conditions, especially when private developers and public authorities seek to combine their efforts. Transferability can be treated a trait that define the way a system reacts to change. Within the domain of SE, transferability is regarded as part of the broader trait of system changeability – a system property supporting lifetime value delivery across changes. Changeability is the ability to alter either the physical design parameters or operations of the system, and can be leveraged in any of the lifecycle phases of common engineering systems: design, build, integration, testing, and operation. Ross et al. (2008) explored the different attributes that makeup the changeability feature of a system (Robustness, Flexibility, Adaptability) and defined "a change" as a state transition, where a system moves from one state to another based on some forces, and as result produces an impact.

Every changeability feature of a system has its own price to be paid in order to enable the transition from one state to another. Given these definitions, transferability can be regarded as part of changeability, thus following the suggested SE approach, can give better insight to the research questions.

Addressing changeability and its implications in the context of JP transferability requires us to explore high-level system design. This, in turn, requires elicitation of the system's design variables (DVs) – i.e., key design features