Professorship of Business Analytics & Intelligent Systems
TUM School of Management
Technical University of Munich

Demand Adaptive Services - Operational Level

According to the United Nations, the global urban population will increase by 900 million from 2020 to 2030, reaching a total of 5.2 billion. This population increase in combination with already high congestion and traffic emissions in cities all around the world calls for novel transportation concepts to keep up with future urban travel demand. Generally, transportation systems consist of infrastructure (roads, railways, ports, etc) and services (buses, trains, trucks, private cars, taxis, metro). Services usually share infrastructure, e.g., buses and cars share roads, metros and trains share railways, etc. In cities, often times infrastructure is the limiting factor which leads to congestion and thus inefficient transportation services. Passenger transportation can be partitioned into two main categories. Personalized Transportation Services (PTS), such as private cars and taxis, are carried out for the mobility demand of a single or a small group of passengers with the same origin and destination, while Mass Transit Services (MTS) offer service for many passengers with different origin and destination. In MTS, passengers share vehicles for part of their trips which leads to a more efficient utilization of the (limited) infrastructure and lower cost of transportation compared to PTS. This effect is especially pronounced in situations with fixed routes and schedules where transportation demand is strong, e.g., there is a consistently high demand over the service area in a specific time window. On the other hand, when the transportation demand is weak, e.g., low demand or low-population density, MTS with fixed routes and schedules uses more infrastructure than needed and the service becomes inefficient.

Demand Adaptive Systems (DAS) aim to combine traditional fixed-line bus services with flexible routes and schedules. In order to do so, a DAS bus line provides a traditional transit-line service for a set of compulsory stops. These compulsory stops are bound to a schedule with fixed time windows during which the vehicle serving the line has to leave each compulsory stop. Additionally, passengers may issue request at so called optional stops which are not contained in the set of compulsory stops and induce detours in the vehicle routes.

Aims and scope of the thesis
This thesis aims to develop an algorithmic framework to solve the following problem: Given a set of compulsory and optional stops, with a schedule for the compulsory stops, derive a strategy to accept or reject requests at optional stops. This comprises the following tasks:

- Formulation of a mathematical model
- Development and implementation of a scalable solution approach, e.g., a (meta-)heuristic
- Evaluation of a Munich bus line
- Discussion of operational and managerial insights

Requirements
This thesis targets students of the TUM-BWL (with a major in Supply Chain Management), Management & Technology, Informatics, Engineering, or similar study programs. Knowledge of mathematical programming, optimization, and a general-purpose programming language (e.g. C++, Java, Python) is required. Prior participation in one of the courses offered by the chair (i.e. Modeling Future Mobility Systems, Advanced Seminar) is recommended. The thesis should be written in English.

Related Research

- Crainic, T.G., Malucelli, F., Nonato, M. and Guertin, F., 2005. Meta-heuristics for a class of demand-responsive transit systems. INFORMS Journal on Computing, 17(1), pp.10-24.
- Errico, F., Crainic, T.G., Malucelli, F. and Nonato, M., 2013. A survey on planning semi-flexible transit systems: Methodological issues and a unifying framework. Transportation Research Part C: Emerging Technologies, 36, pp.324-338.

Begin: As soon as possible

Advisor: Benedikt Lienkamp

Application: See https://www.ot.mgt.tum.de/osm/education/bachelor-thesis/