Time Dynamic Label-Constrained Shortest Path Problems with Application to TRANSIMS: A Transportation Planning System

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(ABSTRACT)

TRANSIMS (Transportation Analysis Simulation System) is part of a multi-track Travel Model Improvement Program sponsored by the U. S. Department of Transportation (DOT), and the Environmental Protection Agency (EPA). The main objective of this thesis is to enhance and implement a principal module in TRANSIMS, called the *Route Planner Module*. The purpose of the Route Planner Module is to find time-dependent label-constrained shortest paths for transportation activities performed by travelers in the system. There are several variations of shortest path problems and algorithms that vary by application, contexts, complexity, required data, and computer implementation techniques. In general, these variants require some combination of the following inputs: a network consisting of nodes and links, and a travel time function on each link, which could be a time-independent or a time-dependent function, where the time-dependent functions account for time-of-day delays resulting from actual travel conditions such as peak-hour congestion. The problem then seeks a shortest path between one or more origin-destination pairs. A new variant, introduced in the context of TRANSIMS and which is the focus of the present study, also specifies labels for each arc denoting particular modes of travel, along with strings of admissible labels that delineate the permissible travel mode sequences that could be adopted by the user in traveling from the origin to the destination of the trip.

The technique adopted by TRANSIMS to identify a suitable travel route for any user is a variant of Dijkstra's procedure for finding shortest paths, which is suitably

modified to accommodate time-dependent travel times and label sequence constraints. The underlying problem is referred to as a Time-Dependent Label-Constrained Shortest Path Problem. The main objective of this research is to improve upon this procedure and study its implementation in order to develop a more effective scheme for determining time-dependent label-constrained shortest paths as a practical routing tool in multimodal transportation networks.

Specifically, we enhance the following features of this procedure:

(a) We recommend a method to work implicitly with a certain composition graph G^* that combines the transportation network with the admissible label-sequence graph. This graph G^* captures all *possible* paths for a given single trip starting from the origin node and ending at the destination node, while conforming with *the admissible mode string*.

(b) We use more modern partitioned shortest path algorithmic schemes to implement the time-dependent label-constrained procedure.

(c) We introduce the notion of curtailing search based on various indicators of progress and projected travel times to complete the trip.

Finally, computer programs in C++ are written to implement the proposed overall algorithm, and are applied to solve some real multimodal transportation network problems. The indicators used to evaluate the performance of the algorithm include (i) time taken for computation on the real network, (ii) quality of solution obtained, (iii) ease of implementation, and (iv) extensibility of the algorithm for solving other variants of the shortest path problem. The results exhibit that the proposed algorithm, even without the approximate curtailing of the search process, exhibits good performance in finding optimal routes for real multimodal transportation networks. Although the various heuristic curtailments result in only approximate solutions, typically, they run much faster than the exact algorithm for the intuitive reason that the shortest path tree developed grows more pointedly in the direction of the destination. Among the different strategies implemented, our results suggest that the scheme based on the geometric structure of the underlying network, using either a constant predictive term, or multiplying this term with a suitable exponential decay function, yields an attractive candidate for heuristically curtailing the search.