Available online at www.sciencedirect.com
ScienceDirect
Procedia - Social and Behavioral Sciences 160 (2014) 529 – 538
Procedia Social and Behavioral Sciences

XI Congreso de Ingeniería del Transporte (CIT 2014)

Shortest hyperpaths in a multimodal network for the public transportation system: Central Southern Mexico City

Minerva Soto Patiño[a]*, Angélica Lozano[a]

[a] *Universidad Nacional Autónoma de México (UNAM), Insitute of Engineering, Torre de Ingeniería Piso 2 ala Norte, Mexico City, 04510, Mexico.*

Abstract

This work presents the implementation of an algorithm to obtain shortest hyperpaths in multimodal networks with a limited number of modal changes, for a real case in central-southern Mexico City. Five public transportations modes without fixed schedules are considered. The outcome for the user is a solution set (Pareto Optimal) with different travel times and number of modal changes, among which user can choose the most convenient for him/her. The implementation result is a set of files that can be used to provide information related to travel decision, and can be the base for creating an Advanced Traveler Information System.

Peer-review under responsibility of CIT 2014.

Keywords: Hypergraph, hyperpath, multimodal transport;

Nomenclature

λ	Path whose nodes represent the stops of a line
Λ	Set of lines of a public mode-*r*
λ_j	Line with stop at *i*

* Corresponding author. Tel.: +52-55-56233600, ext:8382
E-mail address: msotop@iingen.unam.mx

Peer-review under responsibility of CIT 2014.
doi:10.1016/j.sbspro.2014.12.166

Λ_i	Set of lines with a stop at i
Λ'_i	Attractive set of lines to go from i to d
φ_i	Frequency of $\lambda_j \in \Lambda_i$
$\Phi\ (\Lambda'_i)$	Combined frequency of the attractive set Λ'_i
$\pi_j(\Lambda'_i)$	Probability that the first carrier arriving at stop i is from line j
τ_j	Expected travel time between stop-node j and d if λ_j is used (waiting time is not included)
$\omega(\Lambda'_i)$	Average waiting time of attractive set in stop-node i

1. Introduction

In many organized cities, public transportation modes have schedules and the information to develop a shortest multimodal path model is available. In Mexico City, the public transportation system has modes without schedules and vehicles of some modes are not restricted to travel on a specific roads. Hence, it is difficult to know the exact places where lines pass and stop, the places where to do modal transfers, the waiting time at stops and then the time on a path.

This work introduces the implementation of an algorithm to obtain the shortest hyperpaths in multimodal networks, with a limited number of modal changes (Lozano and Storchi, 2002). This algorithm is applied to the real case of central-southern Mexico City, where several public transportations modes without schedules operate. Due to the lack of schedules, the time in between the user's arrival at a stop and the vehicle's arrival to the same stop is unknown. This time is estimated by means the hyperpaths algorithm. The considered modes are metro, BRT, light train, trolleybus and express lines of buses. The algorithm (Lozano and Storchi, 2002) includes a viability prove, which is not incorporated in this implementation due to the considered modes can be taken and left at any stop, without restriction on the sequence of modes on the path. The estimation of waiting times at stops as well as travel times are based on hypergraphs or hyper networks, which use line's frequency of the considered modes. The outcome for the user is a Pareto Optimal set, composed of paths with different travel time and number of modal transfers, among which user can choose the most convenient one.

The implementation result is a set of files, containing shortest multimodal hyperpath information which can support user to take decisions on his/her trip, and can be the base for creating an ATIS (Advanced Traveler Information System).

The rest of the paper is as follows: first some basic concepts of hypergraphs and multimodal hypergraphs are presented, then the implementation of the multimodal hyperpaths algorithm is described, including the modified parts, then the case study is described, and finally the implementation is described, and conclusion is included.

2. Hyperpaths

Concepts on hypergraphs and multimodal hypergraphs are presented below.

2.1. Hypergraphs

Schettino & Pallottino (1999) and Lozano & Storchi (2002) present the theoretical base on hypergraphs and hyperpaths used in this work. Just some of these concepts as presented below.

An *hypergraph* or *h-graph* is a pair $H = (N, E)$, where N is the set of nodes and E is the set of *h-arcs*. A *h-arc* $e = (t(e), h(e))$ is identified by its tail $t(e) \in N$ and its head $h(e) \subseteq N / t(e)$. If $|h(e)| = 1$, the *h*-arc is equivalent to an arc: $e = (i, j)$.

In an *h*-graph, a path q_{od} connecting destination d and origin o is a sequence of nodes and *h*-arcs:
$q_{od} = \left(o = t(e_1),\ e_1,\ t(e_2),\ e_2,\ \ldots, e_m,\ d\right)$, where $t(e_{i+1}) \in h(e_i)$, to $i = 2,\ldots,m-1$, and $d \in h(e_m)$.

A *hyperpath* p_{od} is the minimal acyclic set of paths q_{od}, such that the destination d, is connected to every node belonging to p_{od}.

A *stop-node* is the focal point of public transport service, and the place where people board and leave vehicles.