Transit Timetable for a Park and Ride Scheduled-Bus System for Lagos Island, Lagos, Nigeria

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The city of Lagos, Nigeria and in particular, the Lagos Island offers a typical scenario of chaotic travel pattern occasioned by the large number of car ratio during peak and off-peak traffic flow periods. Amidst several road-pricing and other congestion amelioration schemes under proposal, a personalized public transport scheme which will cater for the travel needs of high class of car users who constitute more than 70 percent of road users is under proposal. Convenience, efficiency and timeliness, which can only be offered by a high-class scheduled bus system, can meet the need of the proposed scheme.

The Simulation study aimed at facilitating the planning of the scheme is in two phases. The first phase deals with the design of transit routes under the characteristic inadequate and sometimes-ambiguous data availability. The second phase, which the presentation in this paper has to do with, is aimed at simulating and analyzing the proposed scheduled bus system using a mixed integer Non-Linear Mathematical Programming approach in order to determine the optimal time table configuration for the system.

The Lagos Mass Transit Project (1992 and 2001) and the Traffic Master Plan for Lagos Island (1994) provide the following traffic network inputs for the simulation experiment: (i). Inflow of vehicles by type to the three major bridges into the Island and the inlets from two other adjacent islands (ii) Vehicle-flows at strategic locations on the Island at different periods (peak and off-peak) for different categories of vehicle. (iii) Vehicle-occupancies for different vehicle categories on different screen-lines used for the projects. (iv) Speeds of vehicles on various links on the network at peak and off-peak periods. (v) Land use characteristics at various zones of the Lagos Island.

A two-phase scheme is also adopted for the current work.

In the first phase Initial Passengers Boarding, Initial Passenger De-Boarding and Transfer Passengers travel parameters are estimated using a novel scheme of fuzzy linguistic land use and socio-economic characteristics as indicators of traffic generators and attractors. The Island is divided into zones around proposed transit vehicle-stops in order to determine linguistic descriptions of land use and socio-economic characteristics such as (i). Commercial/Residential land use (ii) Commercial land use (iii) Government/Social land use (iv) Market land use (v) Markets/Residential land use (vi) Manufacturing land use (vii) Sparse land use (viii) Central Business Activities. Weighted-fuzzy linguistic variables are used to describe the land use and socio-economic characteristics in the suburb of each vehicle-stop (constituting a traffic zone) based on observation, the reports in use and traffic experts' and experienced residents' judgements obtained through structured questionnaires. Relative fuzzy ag-

gregation of the linguistic variables gives linguistic descriptions of the land use as potential generators/attractors of target-human traffic (i.e. car-users) at different vehicle-stop locations and different periods of traffic flow. The fuzzy-linguistic descriptors as represented by de-fuzzified aggregated fuzzy numbers are used as cost-inputs in a Mixed Integer Mathematical Programming Model used to determine expected volume of passengers generated and attracted at a particular traffic zone in the network.

The second phase uses the expected volume of passengers generated and attracted at each traffic-zone around a vehicle-stop, determined in the first phase, as volumes of boarding, de-boarding and transfer passengers for the transit service in the network. Initial Boarding passenger arrival rate at any particular vehicle-station is modelled as a triangular distribution increasing from the time of departure of the last vehicle, peaking at the scheduled vehicle arrival time and decreasing to zero at the scheduled departure time. The peaks of these distributions for each vehicle station within the time interval between departures of vehicles are obtained as a function of the volume of boarding passengers expected between successive vehicle departures. The various categories of passenger volumes determined for a time-tabling period are assumed distributed over different peak and off-peak time-segments according to a custom-built concatenated triangular flow distribution. In the distribution, passenger volume flow increases to a peak and decreases thereafter to a minimum during peak flow time-segments while it decreases to a minimum and later increases to a maximum within an off-peak time-segment. Within a time-segment, the area under the Volume-Time distribution is made equal to the expected volume of passengers. Within a time interval, expected passenger volumes are determined as the area under the distribution.

A mixed integer Non-linear Mathematical Programming is formulated to minimise a combination of the Total Initial Waiting Times and Total Transfer Times of passengers in the overall network to generate optimal time-table for the transit system. Genetic Algorithm is used as the optimal search tool. In the algorithm, headways (taken between 15 and 45 minutes) and stopping times (of between 0.5 and 2.5 minutes) are generated or evolved in binary chromosome strings of the algorithm. These are used to evaluate the objective function of the Mathematical Programming Model over several generations. The generated route-headways determine the time between departures of vehicles at vehicle stops on the route. These in turn determine the Initial Waiting Time for Initial boarding passengers and Transfer Waiting time for transfer passengers between vehicle departures at various stations.

Vehicle capacities on routes are pre-specified. A unifying algorithm is used to tie the simulation of the boarding, de-boarding and transfer of passengers at various stations and on various routes as headways and vehicle-stopping times are generated or evolved for them from one generation of the genetic algorithm to the other. The Unifying Algorithm also keeps tract of boarding or transfer passenger-left-overs, number of passengers on board as well as vacancy on board various vehicles at various stations and time.

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