Optimal Connected Urban Bus Network of Priority Lanes

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ABSTRACT

This work presents a new approach and modeling for selecting an optimal network of public transport (PT) priority lanes. Bus priority schemes and techniques on urban roads and highways have proven effective for almost a half century. Many bus-priority studies have been published and demonstrated worldwide, but none is dealt with optimal connected network of PT priority lanes. The approach used is based on a system-wide concept to result with the optimal PT network coverage. Such a PT priority-lane network will enable fast and less interrupted vehicles movements, increase of reliability of transfers and provide a better schedule adherence related performance. This work develops a model for optimal selection of a set of PT priority lanes that maximizes the total travel time saving and, at the same time, maintains balanced origin and destination terminals given a budget constraint. An efficient CPLEX model is developed and tested. The model was used in a case study of Petah-Tiqwa, a mid-size city of Israel, and produced successfully optimal network of priority lanes.
INTRODUCTION

Bus priority schemes and techniques on urban roads and highways have proven effective for almost a half century. Many bus-priority strategies have been demonstrated worldwide. Traditionally, priority is granted for bus operation at stops, at intersections, and by preferential/exclusive lanes. It is known that bus travel times, reliability of service, and vehicle productivity are improved when buses are able to use higher-speed, uncongested lanes. These improvements make the bus systems more attractive and thus increase the potential to gain new riders (1).

Eight preferential treatments to buses on street lanes are known (2) as follows: exclusive curb lane; semi-exclusive curb lane (shared only with cars about to turn); exclusive median lane (with stop island); exclusive lane in the center of a street; bus malls (limited to pedestrians and buses); exclusive freeway/highway lanes; ramp bypass (for entering a freeway/highway during traffic congestion); and congestion bypass (exclusive lanes to bypass traffic bottlenecks). Some exclusive bus lanes are shared with high-occupancy vehicles (taxis, certain minimum number of people in a car, for encouraging carpools).

Another known type of priority involves BRT (bus rapid transit): a flexible, rubber-tire form of rapid transit that combines stations, vehicles, services, priority lanes, and intelligent-system elements into an integrated system with a unique identity. TranSystems (3) described BRT as a system of buses with such features as signal priority, dedicated right-of-way, automated and off-vehicle fare collection, automated information systems, level boarding, modern vehicles, bus shelters with enhanced amenities, and unique graphics identity (painted on the bus). An example of a successful BRT implementation is that run by the Los Angeles County Metropolitan Transportation Authority, which in 2000 launched the service in several of Los Angeles’ heavy corridors. TranSystem reported that bus ridership in the Wilshire-Whittier and Ventura Blvd. corridors has increased by 20% and 50%, respectively, since the implementation of BRT; furthermore, up to one third of BRT passengers had previously not been transit users.

In Europe, numerous transit-priority projects have been executed; for example, in Athens, Dublin, Munich, Turin, Vienna, and Zurich. Ceder (4) listed the lessons that can be learned from these six case studies in terms of the benefits gained from the implementation of bus priority schemes in these cities; among the results attained are reduction of travel time, increase of patronage and revenue, and increase of average speed.

The first to introduce a system-wide approach for designing priority lanes were Mesbah, Sarvi, and Currie (5-8). In their work, they proposed a bi-level model combining priority lanes selection and traffic assignment.
However, no study has been made about the optimal way to efficiently construct a connected network of bus priority lanes. This is the scope of this work. The objective of work set forth is to examine and find optimally a set of connected urban bus priority lanes at the network level such as to minimize total passenger travel time. This optimal design aims at approaching a metro-like system, but on a bus network, and thus will make the bus system more appealing to use and will improve its image. The concept can apply to BRT lines, ordinary bus lines and a mix of both. Because this work is associated with optimal transit network design in what follows is its literature review.

**Literature Review: Optimal Transit Network Design**

There are two main approaches to restructuring public transit routes: (1) at the route level or for a small group of routes; (2) at the network level. For the first approach, Pratt and Evans (9) suggested that restructuring was to simplify routes, accommodate new travel patterns, ease or eliminate transfers, reduce route circuitry, or otherwise alter route configuration. The present work proffers a practical solution utilizing the second approach.

Prior approaches to the public transit network-design problem can be grouped into those which simulate passenger flows, those which deal with ideal networks, and those based on mathematical programming. *Simulation models* are presented in Dial and Bunyan (10), Heathington et al. (11), and Vandebona and Richardson (12). These models require a considerable amount of data, and their proximity to optimality is uncertain. *Ideal network methods* are based on a broad range of design parameters and a choice of objectives reflecting user and agency interest. Such methods appear in Kocur and Henrickson (13), Tsao and Shonfeld (14), and Kuah and Perl(15). These methods are adequate for screening or policy analyses, in which approximate design parameters rather than a complete design are determined; thus, these methods cannot represent real situations. *Mathematical programming models* are divided into generalized network-design models and transit-specific networks models. Known generalized network models are well summarized and review in Kim and Barnhart (16). The transit-specific network-design models are inevitably heuristic because of the extremely high computational effort required. These partial optimization approaches appear in Lampkin and Saalmans (17), Silman et al. (18), Dubois et al. (19), Mandl (20), and Keudel (21). None of the models and methods mentioned above has actually been applied, however.

In addition is a review below of papers that propose methods of optimizing the configuration of transit-route systems. The output of such methods is a route itinerary that usually includes headways or frequencies.

Baaj and Mahmassani (22-24) develop transit-network-design methods based on artificial intelligence (AI). The methods discussed are developed by a typical formulation of the network-design problem as a programming problem with minimum frequency, load-factor, and fleet-size constrains. The first paper (22) uses flow charts to present a quantitative description of a three-
stage design process for a route network. In the first stage, a large set of routes is generated; the
second stage involves network analysis and a determination of frequencies; the third stage is
network improvement. The second paper (23) focuses on a method of representing the
transportation network by using lists and arrays to make the solution procedure efficient. The third
paper (24) concentrates on the stage of creating the initial set of routes, which are supposed to be
modified now and improved later on. In order to generate this initial route set, a set of basic
skeletons is created along the shortest paths between nodes with high passenger demand; the
skeletons are expanded, using a set of node-insertion manipulations.

Ramirez and Seneviratne (25), using GIS, propose two methods for route-network design
with multiple objectives. Both methods involve ascribing an impedance factor to each possible
route and then choosing those routes that have the minimum impedance. In the first method, the
impedance factor depends on passenger flow and on the road length traveled. This method requires
the use of an assignment model. In the second method, the impedance factor depends on the
number of employees who have a reasonable walking distance from the route.

Pattanik et al. (26) present a methodology for determining route configuration and
associated frequencies, using a genetic algorithm. Solutions are chosen in an iterative process
from a large set of possibilities in which the chances of a solution’s surviving through the iterations
are higher if it yields a high value for a given fitness function. The method presented here adopts
the typical programming formulation of the route-network-design problem with the objective of
minimizing a weighted combination of passenger-time costs and operator-time costs; the objective
function provides the basis for the calculation of the fitness-function values. A methodology is
also presented for the coding of variables as strings with a fixed or variable length.

Bielli et al. (27) describe another method for designing a bus network, using a genetic
algorithm. As in other genetic algorithms, each population of solutions goes through reproduction,
crossover, and mutation manipulations, whose output is a new generation of solutions. In the
proposed model, each iteration involves demand assignment on each network of the current set of
solutions and a calculation of performance indicators based on the assignment results. These
indicators supply input to a multi-criteria analysis of each network, leading to the calculation of
its fitness-function value.

Yan and Chen (28) present a method for designing routes and timetables that aims at
optimizing the correlation between bus-service supply and passenger demand. The method is based
on the construction of two time-space networks: a fleet-flow network and a passenger-flow
network. Both networks are depicted in bi-dimensional diagrams in which the horizontal
dimension represents bus stops and the vertical dimension represents time. While the fleet-flow
network shows the potential activities of the bus fleet, the passenger-flow network illustrates trip
demand. The objective of the model is to feed buses and passengers at minimum cost in both
networks simultaneously. A mixed-integer, multiple-commodity, network-flow problem and a
solution algorithm based on Lagrangean relaxation are presented.
Tom and Mohan (29) continue the development of genetic methods for route-network design. In the current model, frequency is the variable; thus, it differs from earlier models in terms of the coding scheme adopted. Whereas fixed-string length coding and variable-string length coding were used in previous models, a combined route and frequency-coding model is proposed here.

Recently Bagloee and Ceder (30) developed a complete heuristic methodology for a complex problem of transit-network design to handle actual-size road networks. The methodology proposed takes into account the major concerns of the transit authorities such as budget constraints, level-of-service standards and the attractiveness of the transit routes. In addition, this approach considers other important aspects of the problem including categorization of stops, multiclass of transit vehicles, hierarchy planning, system capacity and the integration between route-design and frequency-setting analyses. The generality of the methodology was tested on a real 2010 dataset of the larger city of Chicago, in which a more efficient and optimized scheme was proposed for the existing rail system. The algorithm generated-routes mixed with the existing routes eventually evolved to an efficient scheme in which, with a smaller fleet (21% reduction), the same transportation standard level expected from the existing scheme was obtained. Regardless of other considerations such as “Equity” and “Sustainability”, at least from a purely transportation perspective, the numerical results indicate that the proposed methodology is capable of handling sizable and realistic cases, which was the main objective of their study.

The first to introduce a system-wide approach for designing priority lanes were Mesbah, Sarvi, and Currie (5-8). In their work, they proposed a bi-level model combining priority lanes selection and traffic assignment. The model assesses the impact of exclusive lanes on private cars travel time and optimize the overall weighted travel times and distances. Due to the complexity of the model, heuristics are introduced, such as genetic algorithms. However, detailed and innovative, the model has some issues to consider: a) the model handles two alternatives, namely exclusive or mixed, while it is possible to consider other alternatives, i.e. the eight preferential treatments described in (2), which differ in cost, PT flow, travel time reduction, etc. b) The resulted priority lanes are not necessarily connected (or continuous). It is possible to add explicit constraints, which further increase complexity and model size. c) The priority lanes do not necessarily efficiently cover the network, as the model takes into account travel time reduction alone.

The remainder of the paper is set as follows: an optimal model for connected urban bus priority lanes is introduced, followed by a case study of an Israeli mid-size city, and some conclusions.
OPTIMAL MODEL FOR CONNECTED URBAN BUS PRIORITY LANES

The model's objective is to select a set of priority lanes that maximizes the total travel time saving, while maintaining a balanced origin and destination nodes, given a budget constraint. Each priority lane will have the properties of a path in a graph (31), and must starts and ends at a pre-selected set of nodes serving as terminals of the PT network.

A connected urban bus priority lanes network is a system-wide approach for PT planning. In contrast to micro-level analysis of priority lanes, such an approach increases the PT connectivity level and thus improves the attractiveness of the PT service. That is, the PT connected priority lanes will improve the reliability of transfers made on these lanes with other lines such as feeder buses, BRT, LRT and metro lines (32-34). Moreover, efficient transfers can enhance the overall PT network performance, by providing better coverage and connectivity. Mees (35) introduced the term "network effect" – when the PT network has short waiting times, easy transfers, good coverage, and high reliability – the PT system will be able to compete with the private vehicle. Thus, planning a system-wide priority lanes share the same philosophy.

The network presented in FIGURE 1 illustrates the model. Each arc (between two numbered nodes) is a road section which can be constructed as part of a possible priority lane (exclusive or semi-exclusive). Each priority-lane alternative will be examined in terms of its cost and benefits (time saving). All circled nodes are a set of possible origins and destinations for the priority lanes. The goal is to construct a set of priority lanes that connects PT stations, transfer hubs, routes' start/end stops, and link one priority lane to other priority lanes. By doing so, the PT network will be characterized by uninterrupted routes (such as 15-14-32-13-12-11-33), as opposed to the construction of isolated priority lanes, which often experiencing traffic bottlenecks in the form of non-prioritized sections. Balancing origin and destination nodes is crucial for a well-connected network. For instance, optimizing time saving alone can results with two North-South priority lanes compared with a balanced result of one North-South priority lane and one East-west priority lane; the latter slightly decrease the time saving, but maintain a balanced priority lanes network.

Though the model is designed for priority lanes assessment, it is possible to utilize it for analyzing intersections and traffic lights. In this case, a node (intersection) can be split to two with a connecting arc between its two parts to represent the intersection flow accompanied by cost and benefit.
Model Formulation
Let $G(N,A)$ be a directed network comprises all road sections traversed by PT routes. Let $x_{i,j}^k$ be a binary decision variable, such as "1" represents the selection of priority lane alternative $k$ for road section $(i,j)$, and "0" otherwise. Furthermore, let $c_{i,j}^k$ be the construction costs, $v_{i,j}^k$ the travel time saving per passenger, and $f_{i,j}$ the total passengers' flow of all routes passing through road section $(i,j)$. Let $I \subseteq N$ be a set of all nodes from which a priority lane starts or ends. For constructing paths, let $p_{i,j}^{m,s,t}$ be an indicator whether road section $(i,j)$ is part of path $m$ that start from node $s \in I$ and terminates at node $t \in I$. Matrix P can be easily calculated, as describes in the next sub-section. For clarity the index $m$ will be omitted henceforth. Let $px_{i,j}^{s,t}$ be a decision variable, such as "1" represents the selection of path $m$ that start from node $s \in I$ and terminates at node $t \in I$. Again, for clarity, the index $m$ will be omitted. Furthermore let $B$ be the budget available, and $D_l,D_u$ be the lower- and upper- bounds for nodes' degree.

$$\max \sum_i \sum_j \sum_k x_{i,j}^k \cdot v_{i,j}^k \cdot f_{i,j} \quad (1)$$
\[
\max_{i \in SL} \min_j \left\{ \min \left( \sum_t px^{j,t}, \sum_s px^{s,j} \right) \right\} \\
\text{s.t.}
\sum_i \sum_j \sum_k x^k_{i,j} \cdot c^k_{i,j} \leq B \ \forall i, j \in n \tag{3}
\sum_k x^k_{i,j} \leq 1 \ \forall i, j \in N \tag{4}
\sum_k x^k_{i,j} - \left[ \sum_s \sum_{i,j \in s} \left( p^s_{i,j} \cdot px^{s,t} \right) \right] \geq 1 \ \forall i, j \in N \tag{5}
\begin{align*}
x^k_{i,j} &= \{0,1\} \\
x^{s,t} &= \{0,1\}
\end{align*} \tag{6} \tag{7}
\]

Equation (1) maximizes total time saving resulted from using the selected PT priority lanes. Equation (2) maintains a balanced connectivity between the selected terminal nodes. This balance is maintained by maximizing the minimal in-degrees and out-degrees (the number of nodes directly connected to/from a given node) of all terminal nodes among all feasible solutions (SL). An unbalanced priority lanes set will impact the overall reliability of the PT network and reduce the level of service. Constraint (3) enforces budget availability and constraint (4) maintains the selection of one alternative. Constraint (5) enforces that if at least one path \( \left( \sum_s \sum_{i,j \in s} \left( p^s_{i,j} \cdot px^{s,t} \right) \right) \) from \( s \) to \( t \) is selected (\( px^{s,t} = 1 \)), then one alternative (\( x^k_{i,j} \)) for road section \((i, j)\) must be selected given that the road section is part of path from \( s \) to \( t \) (\( p^s_{i,j} = 1 \)). This constraint also maintains the continuity of each selected priority lane.

Solving multi-objective problems is a complex process (36), hence it is possible to construct a single-objective problem. Hence, equation (2) can be substituted by the following constraints:
\[
\sum_t px^{s,t} \geq Dl \ \forall s \in I, s \neq t \\
\sum_t px^{s,t} \leq Du \ \forall s \in I, s \neq t \\
\sum_s px^{s,t} \geq Dl \ \forall t \in I, s \neq t
\]
Equations (8)-(9) enforce that the out-degree is between upper and lower bounds. Equations (10)-(11) enforce the in-degree bounds. Hence, it is possible to explore different solutions with the adjustments of $D_u$ and $D_l$.

**Paths Enumeration**

The model requires as input of matrix $P$ which is a set of all possible paths (shortest, quickest, etc.) starting at node $s$ and terminating at node $t$. Pre-calculating $P$ will result with an efficient optimal algorithm, because it is not required to calculate on-the-fly paths from $G$. Constructing matrix $P$ is a straightforward process of implementing an all-pairs shortest path algorithm (31), K-shortest path (37), and multiple reasonable routes (38).

**CASE STUDY**

Israel's ministry of transport published in 2011 a call for proposals for a sustainable transportation model city (39). The best proposal will be funded with up to 60,000,000 USD. Mid-size municipalities were candidate for the project. Each participating municipally submitted a proposal covering the following components: 1) priority lanes, 2) advanced technologies for PT, 3) PT network update, 4) improving passengers' infrastructure, 5) cycling lanes, 6) improving pedestrians' infrastructure, and 7) sustainable parking policy. The priority lanes component had the highest impact score of the proposal (30% of the overall score), and described as a major contributor to a successful PT system.

This work on optimal connected urban bus network of priority lanes model was used by the project team that prepared the proposal for Petah-Tiqwa municipally to analyze and recommend a set of priority lanes. The case study of this work is based on the above mentioned project.

Petah-Tiqwa is the fifth largest city in Israel with 211,000 residents, and area of 36 KM$^2$. The city is located in Israel's largest metropolitan area (Gush-Dan). As of 2010, the population's compound annual growth rate was 3.3% (as compared to 1.5% of the total population of Israel). Based on the 2008 census (40), 49% of Petah-Tiqwa's residents worked in the city (~50,000), with additional 84,000 commuters to Petah-Tiqwa from other cities. As of 2008, PT share of the trips was 26%. The city's urban PT network is served by one bus operator. All routes share the road with private and commercial vehicles. A LRT line is being developed, which will connect the city's central station and other municipalities in the metropolitan area as is depicted in FIGURE 2 by a Red Line. Some of the major points of interests, such as bus terminals and industrial parks are
illustrated as well. In order to select an optimal set of priority lanes, the following steps were carried out: (i) selecting road sections candidates for priority lanes, (ii) estimating costs and benefits, (iii) analysis of alternative solutions.

**FIGURE 2** Petah-Tiqwa's Street and PT routes.

**Road Sections Selection**
The road network was analyzed both qualitatively and quantitatively. The former was carried out by the municipally traffic engineers, based on their knowledge, city policy and plans, etc. The latter was carried out based on GIS analysis of PT routes, frequencies, and passengers count in order to locate the most promising road sections in terms of PT flow. The result is a set of road section candidates for priority lanes, both in terms of current PT usages and traffic plausibility. In addition, a set of possible terminals for the priority lanes was selected based on a feasibility study of their best location. Those terminals serve as start and end points for the priority lanes. The road-sections and terminals are illustrated in FIGURE 3.
Estimating costs and benefits

Based on the call for proposal's guidelines \((39)\), two alternatives for priority lanes were analyzed: exclusive lanes (grade-separated busways) and semi-exclusive lanes (at-grade busways). For each alternative one-KM cost was estimated according to a given costs break-down. Thus, for each road-section length-based cost estimation was calculated.

The benefits were calculated as annual time saving (ATS) for distance traveled \((39)\):

\[
ATS = E_1 \cdot MAX (PTE \cdot XE \cdot AE) \cdot PTS \cdot TD \cdot P
\]  

where \(E_1\) is the time saving elasticity of PT, \(PTE\) is the total PT passengers traveling along the road section, \(XE\) is cross-elasticity of vehicle users to PT, \(AE\) is the number of private vehicle users traveling along the road section, \(PTS\) is the time saving for PT users results from a priority lane, \(TD\) is the road section length, and \(P\) is the annual peak factor.

Each alternative benefits were calculated based on the guidelines coefficients for exclusive and semi-exclusive lanes. TABLE 1 provides a sample of costs and benefits per alternative for selected road-sections.
TABLE 1  ROAD-SECTIONS COSTS AND BENEFITS (EXTRACTS)

<table>
<thead>
<tr>
<th>O</th>
<th>D</th>
<th>L [meters]</th>
<th>Semi-exclusive</th>
<th>Exclusive</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td>ATS</td>
<td>Cost [K$]</td>
<td>ATS</td>
</tr>
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<td>1</td>
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<td></td>
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<td>2</td>
<td>6</td>
<td>515</td>
<td>18690</td>
<td>68</td>
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<td>96</td>
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<td>51998</td>
<td>206</td>
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</table>

Analysis of alternative solutions
The optimal model for priority lanes selection, described in the previous section, was used to determine the final selection recommendation. IBM ILOG 12.5 CPLEX (41) is the software utilized. Different budgets and node degrees upper and lower bounds were tested. TABLE 2 summarizes the results of selected scenarios. Each scenario comprises of a budget limit and upper and lower bounds for terminal nodes' degrees (Dl/Du), the actual degrees range and number of zero-degree nodes (Dmin/Dmax), and the annual time saving. The selected scenario is emphasized (with the saving of 3,256,846 pax-km), and presented in FIGURE 4. Dashed lines are the suggested priority lanes whereas the bold lines are road sections not selected due to budget constraints. It is evident that this solution covers all terminal nodes, and because the nodes degrees' lower bound is 1, all terminal nodes are connected at least with another node (both inbound and outbound). For comparison, FIGURE 5 presents a 5M$ solution, in which not all nodes are connected, hence the coverage of the priority lanes is incomplete. Finally, FIGURE 6 provides a graphical representation of the analyzed alternatives and the selected one (emphasized).
### TABLE 2  OPTIMAL RESULTS FOR DIFFERENT BUDGETS AND NODE DEGREES

<table>
<thead>
<tr>
<th>Budget (K$)</th>
<th>D/Du</th>
<th>Dmin/Dmax</th>
<th>Annual Time Saving (Pax x KM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>116,000 (Unlimited)</td>
<td>0/14</td>
<td>14/14</td>
<td>3932159</td>
</tr>
<tr>
<td>58,000 (max. budget)</td>
<td>0/14</td>
<td>0/14 (3 nodes)</td>
<td>3774525</td>
</tr>
<tr>
<td>58,000 (max. budget)</td>
<td>3/14</td>
<td>3/7</td>
<td>3623332</td>
</tr>
<tr>
<td>39,000</td>
<td>0/14</td>
<td>0/3 (3 nodes) *</td>
<td>3473065</td>
</tr>
<tr>
<td>39,000</td>
<td>1/14</td>
<td>1/12</td>
<td>3468331</td>
</tr>
<tr>
<td>26,000</td>
<td>0/14</td>
<td>0/11 (3 nodes)</td>
<td>3332067</td>
</tr>
<tr>
<td>26,000</td>
<td>1/14</td>
<td>1/4</td>
<td>3328767</td>
</tr>
<tr>
<td>21,000</td>
<td>0/14</td>
<td>0/11 (3 nodes)</td>
<td>3260146</td>
</tr>
<tr>
<td><strong>21,000</strong></td>
<td><strong>1/14</strong></td>
<td><strong>1/3</strong></td>
<td><strong>3256846</strong></td>
</tr>
<tr>
<td>13,000</td>
<td>0/14</td>
<td>0/1 (3 nodes)</td>
<td>3130844</td>
</tr>
<tr>
<td>13,000</td>
<td>1/14</td>
<td>1/3</td>
<td>3127544</td>
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<td>5,000</td>
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<td>0/5 (7 nodes)</td>
<td>2510285</td>
</tr>
<tr>
<td>5,000</td>
<td>0/1</td>
<td>0/1 (6 nodes)</td>
<td>2362232</td>
</tr>
</tbody>
</table>

*- More exclusive lanes were selected.

![Selected network of priority lanes](image-url)
FIGURE 5  5M$ network of priority lanes

FIGURE 6  Optimal results for different budgets and node degrees
CONCLUDING REMARK

This work presents a novel approach and modeling for selecting an optimal network of public transport (PT) priority lanes. It is based on a system-wide concept to result with the optimal PT network coverage. The model's contribution, when compared to Mesbah, Sarvi, and Currie's models, is in the introduction of a priority paths, balanced network coverage, multiple alternatives, fast optimal LP modeling, and the use of any saving time model. The model clearly lacks the detailed and direct calculation of travel time change, carried by the assignment model. On the other hand, its simplicity can easily leads to integrating the model with an assignment model. Such a PT priority-lane network will enable fast and fewer interrupted vehicle's movements, increase of reliability of transfers and provide a better schedule adherence related performance. The model is data independent because the cost and benefits of the solutions can be estimated by any program available to the planners. Moreover, the optimization network-based model is fast and easy to implement; it provides a decision support tool for the policy maker. The model was tested successfully for a mid-sized city in Israel as part of planning an urban network of PT priority lanes.

An extension to this study may look for a multi-objective model based on evolutionary algorithms (42-44) and TOPSIS (45) for selecting alternatives from the optimal set. The multi-objective approach can take into account site-specific objectives in the process to select the best network of PT priority lanes or to improve an existing set of priority lanes.

REFERENCES