

OPTIMIZATION OF TRANSIT NETWORKS TO MINIMIZE TRANSFERS

PROBLEM STATEMENT

One of the goals of the Florida Department of Transportation's 2020 Transit Strategic Plan is to help Florida Transit Systems improve their performance. Reducing the number of transfers involved in a transit trip is an important step towards that end. It is widely accepted in the U.S. that the willingness of riders to transfer has a significant impact on the total ridership of a transit system. Thus, the ridership of a transit system may increase significantly merely by reducing transfers through the optimization of the existing transit route network configuration, i.e., without expanding services or demanding more resources.

For transit systems with small bus route networks, a seasoned planner may be able to obtain a reasonable network by utilizing his or her knowledge and experience, carrying out simple ridership data collection and analysis, and following certain simple guidelines. For larger urban areas, where the number of transit routes is close to or over a hundred and where the bus stops number in the thousands, intuition, past experiences, and simple guidelines may not be enough to produce even near-optimal transit route network configurations due to various complicated factors involved in network design. Systematic methodologies are, therefore, needed to improve transit network configurations.

To avoid biases being introduced in heuristic rules, which are commonly used in practice, a mathematical formulation of the optimization problem and a solution search algorithm are essential. The difficulties in transit network design optimization are inherent from the complex characteristics of transit network design realities, which include combinatorial complexity of network solution spaces, nonlinearity of design objective functions or design variables, non-convexity of objective functions or solutions/variable spaces, and multiple and often competing objectives. Until recently, mathematical approaches to transit network optimization have been limited; most are still in the theoretical development stages or, if usable, may be applied only to ideal or small networks.

OBJECTIVES

This research was aimed at developing a methodology and a software tool for optimizing bus transit services to reduce transfers. The specific objectives included the following:

1. Provide an understanding of the current state-of-the-art and the state-of-the-practice in transit network optimization.
2. Develop a methodology for optimizing transit service configurations based on a synthesis/refinement of the state-of-the-art and the state-of-the-practice. The

methodology should have the capacity to deal with a larger transit network than was reported in the literature.

3. Based on the methodologies developed, design and implement a user-friendly computer tool for transit agencies to optimize their bus services with optimal transfers.

FINDINGS AND CONCLUSIONS

This research developed a systematic mathematical statement of the transit route network optimization problems including the definition of various objective functions, solutions search spaces, and constraints commonly used in transit planning. Maximization of transit service coverage, minimization of transfers, and optimization of transit route directness were simultaneously considered. The scheme developed to define the solution search space is flexible and allows the search space to be increased to include more potential solutions as permitted by the computing resources. Several solution search methods based on mathematical heuristics or stochastic methods were also developed. These include greedy search, nearest-first search, hill-climbing, tabu search, and simulated annealing. The methodology and various search methods were tested using previous published benchmark problems and solutions. The results show that this methodology was able improve the solutions obtained from other methods reported in the literature. Additionally, the methodology was also used to solve a large-scale transit network optimization problem based on the Miami-Dade County transit system. The results from this application demonstrate that the methodology is able, in a reasonable amount of time, to improve a given network by increasing service coverage, reducing transfers, and improving route directness.

BENEFITS

The methodology developed in this research has been implemented in a prototype GIS-based program called OPTNet (Optimization Package for Transit Networks). It allows the user to specify street network, transit demand, predefined or preferred routes, fixed routes, initial guess routes, and optimization parameters. OPTNet then produces transit network layout and performance statistics at the network, route, and transfer point levels. With further improvements to the methodology and the computer program, such as the ability to optimize a transit network given a temporal demand distribution and to combine network configuration and scheduling optimization, a practical transit network optimization tool will become available to allow transit agencies to improve their transit services while saving resources.

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