An Efficient VBA Spreadsheet Algorithm and Model for the System Optimum Traffic Assignment

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ABSTRACT

The traffic assignment involves assigning traffic to a transportation network consisting of highways, arterials, or transit routes. To obtain an optimal traffic assignment scheme, a mathematical program (MP) should be formulated and solved. The process of formulating an MP requires identifying all possible paths connecting each origin-to-destination pair through the network, since the number of those paths turns out to be the number of the decision variables. Consequently, formulating and solving such an MP is difficult due to the large number of the decision variables and constraints. For that reason, practitioners prefer heuristics for a large-scale transportation network. In this paper, the authors suggest a new and efficient way of formulating an MP and develop a Microsoft Excel model with Visual Basic for Applications (VBA) to find the optimal assignment scheme for the traffic assignment problem. The developed Excel model with VBA can be easily expanded to a large-scale transportation network.

Keywords: Excel, Heuristics, Mathematical Program (MP), Traffic Assignment, Transportation Network, Visual Basic for Applications (VBA)

INTRODUCTION

In this paper, we consider the traffic assignment problem of assigning traffic to a transportation network. The objective is to minimize total system travel time, subject to satisfying the traffic demand between origin to destination pairs. The problem has traditionally been formulated as a nonlinear integer programming problem with a large number of decision variables and constraints, which makes it difficult to formulate and solve.

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The main objective of this study is to propose a simplified two-phase method of formulating the problem and develop an algorithm using Microsoft Excel model with VBA code to solve the problem with much less effort. The secondary objective is to provide insights to practitioners to show how the Microsoft Excel with VBA could be successfully used in a transportation network model instead of complex mathematical optimization tools such as CPLEX (IBM, 2010) and LINDO (http://www.lindo.com/). For these purposes, we illustrated the efficiency of our approach using a simple Microsoft Excel example with VBA code.

Traffic Assignment Background

Traditional transportation planning consists of the following four steps: trip generation, trip distribution, mode split, and trip assignment (Horvath, 2008). The entire planning area is divided into a number of Traffic Analysis Zones (TAZs). The results from the first three steps are Origin-Destination (O-D) matrices showing the travel demand among those TAZs. Each O-D matrix represents one type of trips, for instance, passenger-car trips. The trip assignment step is to assign the projected travel demand onto the transportation network so that potential problems such as congestion can be identified. In other words, the trip assignment is to predict the number of travelers using various routes and, hence, the traffic volumes on the links of a transportation network. When vehicular trips rather than person trips are estimated, it is called a traffic assignment model (Banks, 1998).

The fundamental aim of the traffic assignment process is to try to predict or reproduce the pattern of vehicular movements that would be observed when the travel demand represented by the O-D matrix to be assigned is satisfied. According to Matthew (2008), the major aims of traffic assignment procedures include:

1. To estimate the volume of traffic on the links of the network and possibly the turning movements at intersections;
2. To furnish estimates of travel costs between trip origins and destinations for use in trip distribution;
3. To obtain aggregate network measures, e.g., total vehicular flows, total distance covered by the vehicle, and total system travel time;
4. To estimate zone-to-zone travel costs (times) for a given level of demand;
5. To obtain reasonable link flows and to identify heavily congested links;
6. To estimate the routes used between each origin and destination (O-D) pair;
7. To analyze which O-D pairs use a particular link or path;
8. To obtain turning movements for the design of future junctions.

The traffic assignment methods are all-or-nothing assignments, incremental assignments, user equilibrium assignments, stochastic user equilibrium assignments, system optimum assignments, and so on. An all-or-nothing assignment is often referred to as the shortest path algorithm. The shortest path, or tree, represents the shortest time path between two zone centroids and is assigned all of the traffic volume between the zones in question. But this method is unrealistic, as only one path between every O-D pair is utilized, even if there is another path with the same travel cost. In addition, as volumes and travel times increase, the results of this method become more unreliable, since the method ignores the fact that link travel time is a function of link volume and where there is congestion or that multiple paths are used to carry traffic. Thus this method will generate unrealistic flow patterns when capacity constraints and congestion effects exist.

The incremental assignment is a process in which fractions of traffic volumes are assigned in steps. At each step, a fixed proportion of total demand is assigned, based on an all-or-nothing assignment. After each step, link travel times are recalculated based upon link volumes. When many increments are used, the flows may resemble an equilibrium assignment. However,
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