1.0 Introduction

1.1 Background

An Origin-Destination (O-D) trip table is a two dimensional matrix of elements whose cell values represents the travel demand between each given origin (row) and destination (column) zone. An O-D trip table can be obtained by conventional surveys such as license plate surveys, home interviews, roadside surveys etc. Such surveys are time consuming, expensive and labor intensive. In addition, many of these approaches involve sampling errors. These conventional approaches also suffer from other drawbacks, such as an inability to reflect changes in influencing factors. For instance, if the land use characteristics change, so will the trip table. Hence the previously measured trip table may quickly become outdated, and one needs to repeat these surveys in order to obtain new trip tables, which is cost prohibitive.

Nevertheless, many transportation organizations require the trip tables for planning purposes. Due to constraints in budget, time and labor, researchers began exploring alternative means of producing these trip tables. Since the early 1970's several techniques have been explored to obtain the trip table without the need for expensive surveys, as will be described further in the literature review.

1.2 Need for O-D Trip Table

Traffic congestion is one of the major problems faced by both developed and developing countries. Several potential solutions have been investigated to solve it, and a great deal of effort is put into activities such as, transportation planning to transportation management in order to attempt to alleviate the problem. Some solutions include: demand restriction policies (such as increasing taxes or increasing other transportation

expenses, ramp metering), increasing transportation supply, improved transportation management strategies (such as better signal coordination, real time traffic diversion) and recently development of ITS (Intelligent Transportation Systems). Most transportation problems are complicated. However, solutions to them are costly when put into practice, prohibiting trial and error approaches to finding the best solution, as a careful investigation is needed to understand the effect of relevant demand and supply before any strategy is implemented.

Demand information in transportation planning is described by trip tables. There are two types of trip tables; Production–Attraction (P-A) trip tables and Origin-Destination (O-D) trip tables. The main difference between the two is that the cell values in a P-A trip table are non directional, whereas the cell values of an O-D trip table have directional meaning, indicating the number of trips going from an origin to a destination. Further more, a P-A trip table satisfies flow conservation, i.e. the summation of productions must be equal to summation of attractions, whereas an O-D trip table does not exhibit such a property.

O-D trip tables are generally used for traffic assignment purposes. During the past few years many transportation engineers have begun to focus on Intelligent Transportation Systems (ITS), which include Advanced Traffic Management Systems (ATMS), Advanced Traveler Information Systems (ATIS) and Automated Vehicle Control Systems (AVCS). It is believed that accurate and fast O-D trip table generation techniques are needed, in the planning, operation and maintenance of such ITS.

There are many methods to obtain O-D trip tables based on link counts. One of the most popular techniques is the one using the maximum entropy approach to obtain an O-D trip table. Many formulations based on the maximum entropy approach have been put forth and various assumptions have been made in order to simplify the formulations. These simplifications are done in order to aid the process of obtaining a solution quickly. The various formulations are investigated for their accuracy and applicability under various circumstances. The thesis objectives are outlined below.

1.3 Thesis Objectives and Contributions

As described in the previous section, accurate and fast O-D trip table generation is needed for effective planning and management of transportation systems. Here we are using the maximum entropy approach to obtain O-D trip tables based on link counts. Many formulations have been put forth, and various assumptions have been made. Most of the formulations and assumptions are scattered in different research papers. This thesis derives the various formulations and states their assumptions and the limitations of obtaining O-D trip tables quickly based on the maximum entropy approach. A proposed numerical approach is compared with the existing formulations to understand the relative merits and demerits between them. This thesis also studies the impact of uniform seed, feasible seeds and infeasible seeds as being the prior or target trip table.

This advances the understanding of the strengths and weaknesses of using a particular formulation. Further, this helps in deciding which of the formulations would be effective from a computational stand point, as one of the aims is to obtain O-D trip tables quickly.

1.4 Thesis Organization

In order to achieve the above objectives, a literature review was first conducted to understand the many approaches to obtaining O-D trip tables based on link volumes. The various formulations to obtain O-D trip tables based on maximum entropy techniques were then gathered. The formulations were than tested on two sample networks and their effectiveness studied under various conditions.

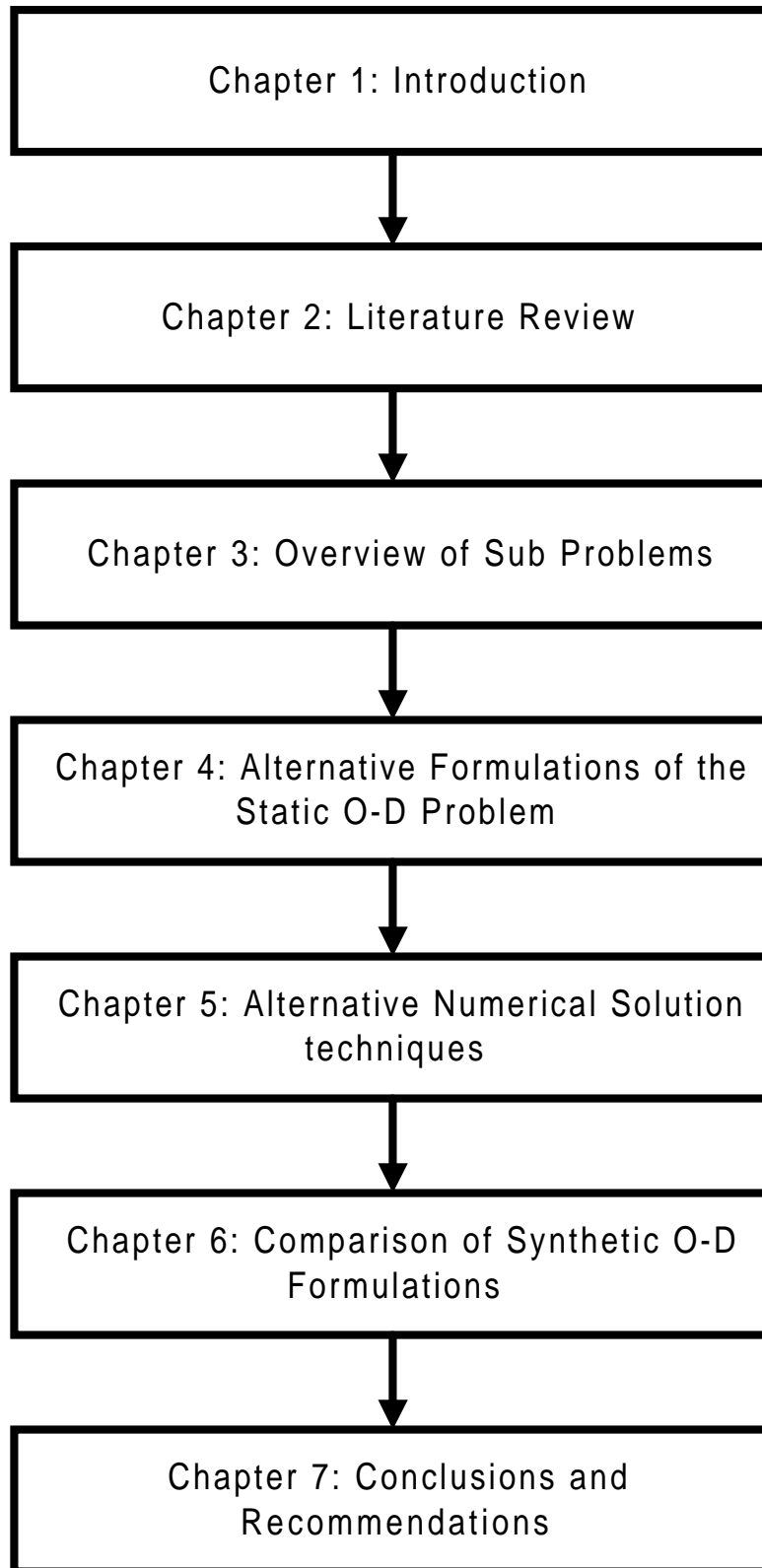The thesis is organized as shown in Figure 1.1 and as described below.

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│         Chapter 1: Introduction          │
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│       Chapter 2: Literature Review       │
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│    Chapter 3: Overview of Sub Problems    │
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│   Chapter 4: Alternative Formulations of  │
│          the Static O-D Problem           │
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│   Chapter 5: Alternative Numerical        │
│           Solution techniques             │
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│   Chapter 6: Comparison of Synthetic      │
│           O-D Formulations                │
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│      Chapter 7: Conclusions and           │
│            Recommendations                │
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Figure 1.1: Flow Chart of Thesis Organization

Chapter 2 contains a summary of the literature review performed for this thesis. This includes the various classification of the various models to obtain synthetic O-D trip tables based on link counts. The advantages and disadvantages of each model are also discussed. The types of algorithms used are also mentioned.

Chapter 3 provides a detailed description of the sub problems which need to be kept in mind, when dealing with this overall problem. This includes a comparison between trip distribution and synthetic O-D generation methods, the implications of multiple solutions to the problem, and the issue of flow continuity in networks.

Chapter 4 discusses in detail the Maximum Entropy or Information Minimizing technique to obtain O-D trip tables based on link counts. A detailed derivation of both the trip formulations as well as the volume formulations is presented. The various assumption made, as well as some suggested improvements, are also discussed.

Chapter 5 presents proposed numerical approaches to solve the O-D problem, which includes detailed descriptions of the new formulation. Two different solution approaches are described, and the relative merits and demerits of these formulations are presented. Computational strengths of some software tools, like MATLAB, MS-EXCEL Solver etc, that are used to solve this problem are also discussed. Further some aspects of solver attributes are presented.

Chapter 6 compares the solutions obtained by various formulations on two networks. The effects of the prior trip table being uniform, feasible or infeasible are also discussed. The proposed numerical approach is compared with the various other formulations to test its effectiveness. In addition, the consistency between the trip formulation and the volume formulation is established. The appropriateness of the assumptions is also discussed.

Finally, Chapter 7 summarizes the conclusions made in the previous chapters and provides recommendations for further research.