Comparing Transit on Demand and the current standard of mass transit

Key words: transportation sustainability, mass transit, intelligent transit, transit-on-demand, demand-responsive transport, vehicle routing problem, dynamic routing

Introduction

As traffic congestion continues to worsen in cities nationwide and the distance traveled by the Single Occupant Vehicle (SOV) mode continues to increase [1], mass transit as a mode of travel looks increasingly important as a means by which to achieve transportation sustainability. Decreasing the reliance on automobiles with single occupants in the nation’s cities provides benefits to society by reducing energy usage, dependence on foreign resources, climate-altering emissions, lung-irritating pollutants, social exclusion, and time spent captive, away from social interaction or productive pursuits. If the percentage of trips undertaken (mode share) via mass transit is to be increased, providing efficient, effective transit service is a requirement. Two barriers preventing such an increase are the lack of service to some areas of cities, which creates “automobile captives” [2], and the fact that for many trips for which service does exist, there is a large difference in travel time between mass transit and private auto.

Hypothesis

A transit-on-demand (TOD) system, in which a) riders request pickup and dropoff service at the time of their trip, b) trips are dynamically assigned to GPS-equipped vehicles and c) vehicles are dynamically routed to pick up and drop off riders would provide more service to an urban area at the same level of efficiency as the current system of static, pre-determined routes.

Research Plan

Strategy

The research will consist of the modeling of a TOD system for real cities and comparing the level of service and efficiency to that of those cities’ existing transit systems. Using geographic information system (GIS) data for real cities selected for varying spatial characteristics and current levels of transit service, trip requests consisting of an origin and destination will be generated. Algorithms for the Pickup and Delivery Problem (PDP), in which vehicles must be routed to minimize cost while picking up and delivering goods, and the Dial-a-ride problem (DARP), a variant of the PDP where the goods are people (both of which are active, popular topics in operations research), will be used to route vehicles to service requests. To date no such simulated comparison of dynamic on-demand versus fixed-route transit service has been published.

Methodology

Trip request generation for the model will be approached in several ways to test the robustness of the system. One will be a purely random spatial distribution; another will use census-block-level data for home and workplace location from the Census Bureau’s Longitudinal Employer-Household Dynamics Program to simulate home-to-work trips; and the last will heavily weight demand in some areas to see how well the system responds to localized “overload”.

Incoming trip requests will be assigned to vehicles in batches at some interval (e.g. every five minutes) by a central system which will utilize one of the PDP or DARP algorithms, or some variant of either. A sub-objective of this research will be to choose the most appropriate algorithm considering travel time, distance, and a user
inconvenience function that takes into account the difference between the shortest possible time from origin to destination and the actual time based on the calculated route.

The efficiency of the modeled TOD service will be determined in terms of vehicle-miles-traveled (VMT) per level of service to account for fuel and maintenance costs and emissions and as the number of required driver man-hours per level of service to account for personnel costs. Level of service will be defined in several ways, including number of trips served and geographic area served.

**Controls**

Current mass transit systems in the study cities will be compared to the TOD system as a control using the same efficiency measures.

**Anticipated Results and Extensions**

The anticipated result is that the TOD system will have significantly higher efficiency than the current standard of mass transit. This means that by implementing such a system, a city would significantly improve the level of transit service, and thus increase transit mode share, without any cost penalty. An additional broader impact of the implementation of such a system, even if only as a pilot project, would be the creation of a rich collection of data on the travel behaviors of urban travelers. It would provide, longitudinally, the origins, destinations, times of departure, and potentially (if the mode of implementation required some kind of unique traveler ID) even travel patterns for individuals. Further, such a TOD system could be expanded to include not only standard transit vehicles (i.e. buses), but taxis, and even personal vehicles, creating a smart carpool system. Such an arrangement would dramatically increase transportation efficiency using existing physical infrastructure by adding only information technology infrastructure.

**Originality of research proposal**

This research plan grew out of my research co-op (described in the Previous Research essay). It will constitute a novel contribution to the fields of transportation planning and operations research. Literature searches have uncovered no other comparison studies between TOD and current systems of mass transit. Several articles [3 & 4] have tested actual implementations of TOD systems on a pilot basis, and another [5] has modeled the efficiency of various trip assignment algorithms, but none have made direct comparisons between a TOD system and standard fixed-route transit systems.

**Literature Citations**