Title: Efficiencies in Freight and Passenger Routing and Scheduling

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Project Objective

The objective is to develop routing techniques that react better to uncertainties in demand to improve the operations of the trucking industry in terms of reducing vehicle miles, thus minimizing the impact of freight on passenger travel since they primarily share the same road network, especially in major urban centers like Los Angeles. We propose an optimization-based look-ahead vehicle routing framework that models and solves the dynamic vehicle routing problem by employing existing heuristics in the literature that are originally designed to solve static vehicle routing problems. In order to generate better solutions for problems with various degrees of uncertainty, the behavior of the proposed framework is tunable by adjusting different parameter settings of the framework and the heuristics.

Problem Statement

The growth in the number of containers has already introduced congestion and threatened the accessibility to many terminals. The congestion at a port, in turn, magnifies the congestion in the adjacent metropolitan traffic network. At the same time, more and more container terminals require Just-In-Time (JIT) cargo delivery and pickup due to advances in information technologies and limited space for storing inbound and outbound containers. At the same time, the highly competitive trucking industry is driven by the need to satisfy consumer demands and to operate at the lowest possible cost at the same time. In addition, logistic service providers (LSP) face uncertainties throughout various stages of operation. These facts magnify the need for finding better ways of performing truck operations in metropolitan areas adjacent to the ports. The increasing level of freight transportation also aggravates its impact on traffic congestion, and poses threats on the safety and efficiency of passenger traffic and other social functions that share the same road infrastructure. This phenomenon becomes more significant in densely populated urban areas, like Los Angeles.

In this research, we aim to model and solve a truck routing problem that is representative of the daily operation of many logistic service providers, especially those who consolidate shipments from multiple suppliers. Suppose a trucking company operates a fleet of homogeneous vehicles to collect shipments from a known set of suppliers and transport the shipments back to a central depot. These suppliers can be seen as registered customers of the company. Their locations and service time windows are known and fixed. However, each customer may not request service on each day. How often each customer requests service is determined by his/her own operation schedules, and can be seen as a given parameter in our problem. If a customer requests service, it can either do so at the beginning of the day (before the vehicles leave the depot), or at any time during the day. Customers who have requested service at the beginning of the day are called *advance* customers and must be serviced. All other customers, called *dynamic* customers, may potentially request service, but the company does not know whether and when they will do so. The company may have to reject a dynamic customer when he/she requests service if his/her shipment cannot be accommodated. The situation described above can be modeled as a Dynamic Vehicle Routing Problem (DVRP). A DVRP is derived from a VRP when some information in the problem is revealed dynamically over time, instead of known before the vehicles are dispatched. In our problem, the set of customers needed to be serviced is random.

Research Methodology

In order to effectively model and solve the dynamic vehicle routing problem (DVRP) involving both known and dynamic customers, we have setup multiple objectives to meet. First, we want to minimize the impact (on the efficiency of the routing schedules in terms of vehicle miles) of knowing only partial information. Second, we want to maximize the flexibility of our solutions in a dynamic environment. Third, we want to provide fast responses to the dynamic customers when they request service, since these requests are being made in real-time. We have developed an optimization-based, look-ahead dynamic, partial vehicle routing framework. We constructed a rolling horizon framework embedded with partial vehicle routing problems (VRPs), which contains both known and forecasted information. We then developed three solution modules that sequentially and periodically construct and solve the partial VRPs. Another module was developed to handle dynamic customer orders. Figure 1 illustrates the time dynamic of the solution modules.

Results

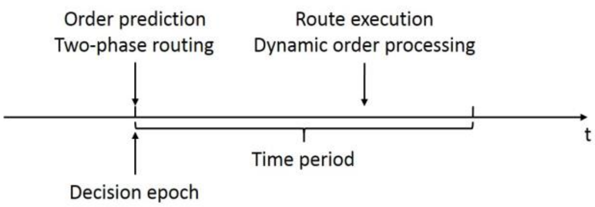
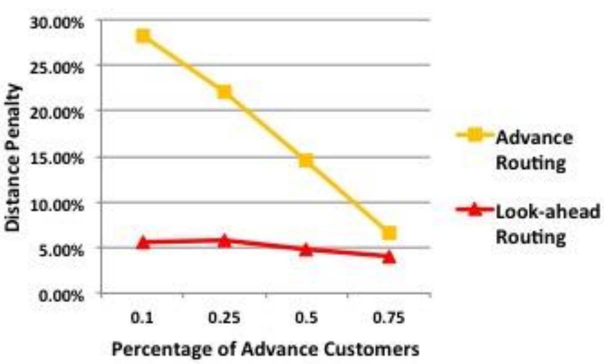


Figure 1 Time dynamic of solution modules



We perform simulation experiments on well-known benchmark problem instances in the literature. For each instance, we compare the quality of our solution with other routing strategies. We see that the look-ahead routing strategy with forecasting of future requests outperforms a routing strategy that only makes use of the known demand information, in terms of total travel distance for instances with relatively fewer advance requests and more dynamic requests. Thus the look-ahead dynamic routing strategy shows its merits for problems with high level of uncertainty. Overall our proposed approach could generate routing solutions that could reduce freight vehicle miles traveled, thus minimizing the impact of freight on passenger travel since they primarily share the same road network, especially in major urban centers like Los Angeles.