Project Summary:

Optimal Transportation Portfolio Management at Walmart Stores

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Abstract

Walmart Stores partnered with MIT to improve their truckload transportation procurement process. The team designed, developed, and implemented a software tool to optimally allocate both private fleet and for-hire carrier assets across Walmart's network considering uncertainty of demand. Implemented in 2011, the tool has reduced required planning time by 75% and has led to repeatable savings of $15-$25 million annually.

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Introduction

Retailers must move goods from vendor locations to their stores as efficiently as possible in order to remain competitive. Therefore, the procurement and management of truckload transportation is a core competency for retailers of any size. Securing truckload contracts usually entails the use of sophisticated optimization based software that enables the shipper to trade-off cost, service, and other business imperatives in the assignment of for-hire carriers to specific lanes.

Walmart Stores is no different than other retailers in this respect. They have been using optimization-based procurement software as part of their planning process since 1997 and have typically run a national truckload auction every two years.

Walmart, however, identified three challenges to its current procurement process. First, they operate a very large private fleet in addition to using for-hire carriers. Private fleet assets, unlike for-hire carriers, need to be managed in terms of tours that start and end at a common domicile location rather than as discrete, point-to-point lane assignments. Traditional optimization based procurement tools are designed for for-hire carrier assignment and do not consider different asset classes, such as private fleet. Walmart identified the need for a more economically rational allocation of private fleet and for-hire carrier assets across their network.

Second, Walmart faces uncertainty in demand across their different lanes. The success of private fleet assets is highly dependent on the reliability of the underlying demand on the lanes within a multi-leg tour. Walmart identified the need to consider the variability of demand in the assignment of private fleet assets to their network.

Finally, Walmart is exceptionally large and consumes a tremendous amount of diverse transportation resources. In a given month, Walmart receives on the order of 315,000 inbound loads from vendors and delivers 120,000 loads to its stores. Walmart's own fleet consists of more than 6,000 tractors and 55,000 trailers domiciled at dozens of locations. Additionally, Walmart operates over several distinct networks, such as Grocery, General Merchandise, Apparel, Import, etc. Coordinating and managing these different asset classes across multiple complex networks involving various teams is exceptionally time consuming. Walmart identified the need to be able to speed up this allocation and coordination process across the entire company in order to focus more managerial time on critical issues.

Walmart teamed up with the MIT Center for Transportation and Logistics (CTL) in 2008 to improve their already strong transportation procurement and planning processes. Specifically, the combined team designed, developed, and implemented a software tool (Fleet Network Optimization Tool or FNOT) to meet these three challenges. FNOT uses a large-scale optimization algorithm inspired by column generation that allows planners to determine the optimal allocation of fleet and for-hire carriers. FNOT can consider uncertainty in the network demands through the use of either historical demand patterns or a theoretical distribution.

Model Description

The Fleet Network Optimization Tool (FNOT) is built around a linear programming model that takes as input the historical (or a theoretical) distribution of the weekly truckload demand on each network lane. The model creates fleet tours that start and end at each of the several dozen domicile locations and comply with Walmart's business preferences and US Department of Transportation's driving rules. Each of these tours represents a column, in the column generation sense, to be fed into the model.

The model distributes the lane demand across all of the relevant tours that include that particular lane. The distribution is probabilistic in the sense that a penalty is assigned to any expected uncovered demand on each lane. The expected uncovered demand is in fact the non-linear loss function obtained from the probabilistic distribution of the lane demand while the penalty is the for-hire carrier rate for that lane. By creating a piece wise linear approximation of the loss function we can model continuous probability distributions by selecting enough points on the curve while discrete distributions with finite domains (such as historical demand) can be represented exactly by creating a constraint for each point on the distribution with non-zero probability. The probabilistic features are modeled through constraints in the linear programming model. Following traditional column generation methodology, more and better tours are generated using heuristic algorithms along with the expected dual prices obtained from the linear programming model.

The back-haul concept serves as the bridge between the optimization and Walmart's fleet planning needs. Most of the fleet is committed to handling moves between the distribution centers and the store. Whenever possible it is better to send a fleet truck to pick up a load heading to its home distribution center rather than return empty. Walmart has been conducting marginal cost analysis to decide which back-hauls are in fact economical. The project team proved the identity of the marginal costs obtained through this method with dual prices obtained from the LP model. Furthermore, we showed that the model's dual prices allow for the analysis of more complex tours than were possible before and also incorporated the cumulative network effects of all moves in the system.

The network dimensions for which FNOT is run are over 20,000 lanes, 6700 locations and 115,000 moves per week. The typical optimization model generated has more than 110,000 constraints and up to 1.7 million tours. The usual run time in a Xenon class multi-core processor is about 2 hours.

Implementation & Impact at Walmart

The FNOT model was implemented at Walmart in 2011. In just over a year of full use it has not only had significant direct financial impact, it has also dramatically improved the way in which Walmart manages its vast portfolio of different transportation resources across its networks.

Prior to FNOT, the annual transportation procurement process would begin with a manual and time consuming analysis of the historical shipments from the previous time period by the various fleet teams. They would carve out the lanes that they wanted to haul, leaving the rest for the for-hire carriers. This process involved a great amount of back and forth discussions and would take four weeks. Then, the for-hire lanes were fed

into the combinatorial auction tool and a bid would be held. At the end of the bid, the fleet teams would yet again review these lanes to see if they wanted to convert some of these newly bid for-hire lanes to fleet lanes. The determination of fleet versus for-hire lanes was a contentious, complicated, and time-consuming negotiation between the fleet and the corporate transportation teams within Walmart.

FNOT has simplified this process so that it now takes just one week with fewer resources. It has eliminated the back and forth debate by serving as "the one version of the truth" for any fleet versus for-hire discussions. A new Fleet Optimization Team was established around FNOT to enable these decisions. The process is now 75% faster and has transformed what was once a fractious debate into an exception-based review. This allows for quicker identification of and greater in-depth analysis of the more critical issues by the senior transportation executives at Walmart.

FNOT has been used in three procurement events covering both dry van and refrigerated transportation over the last 18 months. In each case, FNOT recommended both additions to and deletions from the various fleets' networks. The net effect of this rationalization was an increase in the use of fleet assets, but on more economically aligned lanes. Walmart estimates it has and will continue to save between $15 and $25 million per year going forward.

While the model was originally designed only to optimize the private fleet assignment, it can be used in a number of unintended, and beneficial, ways. For example, the tool is being used to analyze pickup allowances provided by vendors to determine if they are reasonable or not. The FNOT model compares the marginal fleet cost for handling a lane (using the expected dual prices) to the vendor's pre-paid allowance.

Overall, the project has been successful in four ways. First, it delivered financial results many times the investment in the development, design, and implementation – and will continue to do so for years to come. Second, it dramatically streamlined and improved the process by which Walmart allocates the different transportation assets within its portfolio so that senior management can spend more time on critical issues. Third, it is enabling the Walmart transportation teams to explore new and unexpected sources of efficiency and opportunities across their immense freight distribution network. These new opportunities could, in the end, dwarf the results already achieved. Finally, this project has led to a deeper partnership between Walmart and MIT CTL that includes sponsoring student thesis projects, attending symposia and conferences, and participating in research initiatives.