

DISSERTATION PROPOSAL

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“Models and Methods for Omni-channel Fulfillment”

Friday, February 26, 2016

1:30 PM

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Omni-channel retailing, the combination of online and traditional store channels, has led to the use of traditional stores as small fulfillment centers for online orders and as transshipment points for inventory re-balancing. My dissertation focuses on new research questions related to the acceptance and fulfillment of orders in omni-channel retail.

A key aspect of the problems I study in omni-channel fulfillment is the cancellation of accepted online orders. Cancellations occur for a variety of reasons, including stocking out due to serving walk-in demand with higher priority than online demand. A recurring theme across the different models I study is the tradeoff between cancellations and profits: a riskier fulfillment policy may result in more online sales but also more cancelled orders.

In my first chapter, I apply techniques from machine learning and discrete optimization to find omni-channel fulfillment policies that perform well empirically at maximizing revenues subject to a constraint on cancellations. Using real data collected by a high-end North American retailer, I build estimators that predict the cancellation probability of incoming online orders. Next, I formulate and solve an optimization problem based on these estimates to get a fulfillment policy. Simulation results demonstrate that this fulfillment policy performs well compared to several other baseline approaches. I propose to consider additional machine learning models for predicting cancellations and to extend my simulation methodology to better address the issue of censored demand data.

My second chapter builds a stochastic model of the process leading to order cancellations for a single item so that retailers may find inventory and fulfillment policies that effectively use this additional information. I consider both settings where the demand distributions are known and unknown to the retailer. When demand is known, I aim to find closed-form solutions to minimize expected fulfillment costs, and when demand is unknown I prove bounds on the number of samples from the unknown distributions needed to obtain near-optimal solutions. I present results in both settings for a single-period single-location model, and I propose to extend these results to multiple-locations and multiple-period models.

The third chapter studies models and algorithms for a similar optimization problem designed to perform well in the worst-case. Rather than assuming demand is drawn from a fixed probability distribution, demand comes from an unknown source, perhaps in an adversarial manner. I present an online algorithm that is $\frac{1}{2}$ -competitive for maximizing revenues in this model. This algorithm does not currently take advantage of a form of recourse available to the retailer in this model, and so one proposed question is whether an algorithm exists with a better competitive ratio that takes advantage of this feature. I also study an alternative version of this model where the objective is to minimize costs. I plan to construct an algorithm that achieves the same or an improved competitive ratio to my preliminary result while removing an assumption currently in the model.