Fulfillment source allocation, inventory transshipment, and customer order transfer in e-tailing

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ABSTRACT

We consider an inventory fulfillment-allocation and transshipment problem in an e-tailing environment. For a typical e-tailer, each customer demand is fulfilled from the closest fulfillment center if there are enough inventories. Otherwise, the e-tailer would transship stock from a nearby facility or transfer the customer order so it is fulfilled from another facility, depending on the economics of transportation. We develop a mixed-integer programming model to help e-tailers optimally fulfill customer orders while minimizing logistics costs. We propose a Benders decomposition-based approach to efficiently find optimal solutions. Our computational results demonstrate the importance of considering inventory transshipments in online deliveries.

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1. Introduction

Now that the initial e-commerce hype has settled down, we are able to identify some of the operational benefits and challenges of having an e-tailing channel. From an operations management perspective, one of the advantages brought by an e-tailing outlet is the opportunity to make use of demand data between the time when it has been revealed through an online order and before the order has been fulfilled. While in a traditional store setting the retailer cannot make significant decisions between the time a customer walks into the store and the time the customer leaves, in an online setting the retailer has an opportunity to decide about how to best fulfill the order while the customer is conveniently waiting for delivery. We call this time the *window of decision opportunity* as depicted in Fig. 1. It is evident that some e-tailer, such as Amazon, do use this window to make decisions on how to efficiently deliver the customers' orders. To help in its decision making, Amazon asks a customer, who has purchased several items, to choose between two options: (1) "Group my items into as few shipments as possible" and (2) "I want my items faster. Ship them as they become available (at additional cost)". Clearly, for Amazon shipping the items in a bundle would cost less, but they still provide the less efficient option (shipping items possibly individually) to their customer if quick delivery is important for them, albeit at a premium. Amazon is reported to rely on complex predictive modeling and optimization models to efficiently allocate and deliver inventory on time to its customers (e.g., Sanders, 2014, p. 38).

We note here that the window of decision opportunity could be common for a group of orders or different for each customer's order. However, in practice, the first scenario is more likely to happen with an e-grocer where the deliveries are arranged in a manner that would provide enough time for orders' consolidation. For example, an e-grocer might set the order

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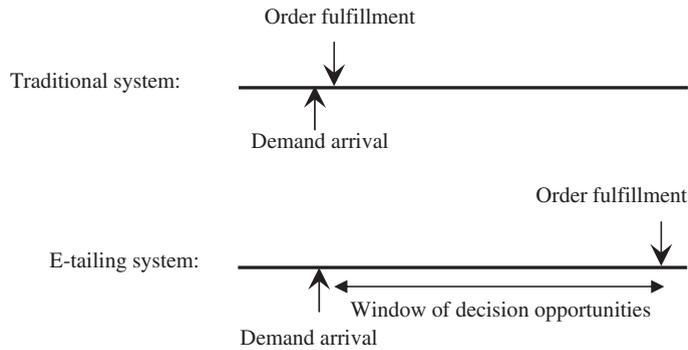
Fig. 1. Window of decision opportunity.

placement limit for 8:00 AM next-day deliveries to be 10:00 PM the night before. Thus, this e-grocer would have the time interval 10:00 PM–8:00 AM as the window of decision opportunity at each review period. An example of such delivery schedule is shown in Fig. 2.

On the other hand, companies such as Amazon and Dell may have a different window of opportunity for each (or a group) of their customers. For such companies the high volumes can provide a steady stream of orders that can be grouped through different decision windows to benefit from consolidation and transshipments. In this study, for the sake of simplicity, our focus is on a window of decision opportunity that is common for a group of orders.

The decisions opportunities that are available to e-tailers in the above context are generally related to the different steps of order fulfillment process in the e-commerce environments which could be detailed as follows:

1. *Source of fulfillment*: After the online demand is realized, the e-tailer can compare the order sizes to the available stocks at different locations to check whether or not the supply can match the demand. Since for the online customer it is immaterial where the product will be coming from, the e-tailer can decide about which fulfillment center is the most efficient source for satisfying an order. This allows the e-tailer the luxury of aggregating inventory without having to physically store it in one location, often referred to as *virtual aggregation* (Chopra and Meindl, 2013). In the event that there is a shortage at one location, e.g., the location that is closest to the customer, the e-tailer can decide about how that shortage will be met through *substitution* or *transshipment* or a combination.
2. *Temporary shortage allocation*: When there is a temporary total shortage at different locations (i.e., the system-wide demands exceed the total available inventory), then the e-tailer can decide about how much shortage will be allocated to each customer depending on their shipment preferences and the quoted delivery times at ordering.
3. *Planned substitution*: Given the online customer's willingness to substitute between similar products, the e-tailer can use this knowledge to systematically decide about the rate (or amount) of substitutions. While substitution is possible with a traditional retailer, unlike a store customers who make their substitution decisions, in an online setting it is the e-tailer
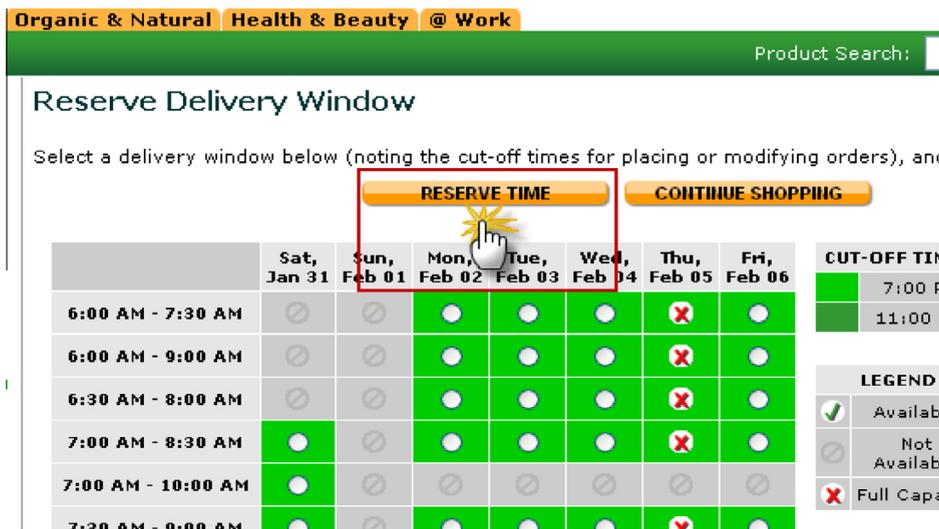

Fig. 2. Delivery windows for GroceryGateway.com.