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Applications

Improving routing and scheduling decisions at a distributor of industrial gasses☆

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Abstract

This paper investigates cyclical inventory replenishment for a company's regional distribution center that supplies, distributes, and manages inventory of carbon dioxide (CO_2) at over 900 separate customer sites in Indiana. The company previously experienced high labor costs with excessive overtime and maintained a regular back-log of customers experiencing stockouts. To address these issues we implemented a three-phase heuristic for the cyclical inventory routing problem encountered at one of the company's distribution centers. This heuristic determines regular routes for each of three available delivery vehicles over a 12-day delivery horizon while improving four primary performance measures: delivery labor cost, stockouts, delivery regularity, and driver–customer familiarity. It does so by first determining three sets of cities (one for each delivery vehicle) that must be delivered to each day based on customer requirements. Second, the heuristic assigns the remaining customers in other cities to one of the three "backbone routes" determined in phase 1. And third, it balances customer deliveries on each daily route over the schedule horizon. Through our methodology, we were able to significantly reduce overtime, driving time, and labor costs while improving customer service.
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1. Introduction and company background

In recent years, several suppliers have taken on the responsibility of managing inventories of their own products at customer sites. These vendor managed inventory (VMI) environments have several documented benefits on supply chain performance. The most commonly cited benefits include lower inventory holding costs, fewer stockouts, increased supplier competition, improved service level, and reduction of demand distortion. Non-VMI suppliers that respond to fluctuating customer orders must constantly schedule and coordinate a changing pattern of delivery shipments. VMI suppliers, on the other hand, have more control over when and where inventory will be delivered. As such, VMI provides the supplier increased latitude in scheduling deliveries, as opposed to reacting to customer-placed orders. In addition, when deliveries may be made to several customers by a single vehicle, coordinating delivery routes and schedules can bring about significant distribution cost savings [1–3]. However, VMI also places

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additional pressure on the supplier to ensure no stockouts occur for the customer since allowing a stockout can mean decreased service levels, reduced sales and loss of customer goodwill. In this context, determining the day and place to deliver is not an easy task, especially when resources are limited and certain service levels must be met. In this paper, we facilitate this decision by devising and implementing a three-phase heuristic for a vendor that faces the problem of managing and distributing a single product.

The company with whom we worked is a supplier and distributor of carbon dioxide (CO_2) products across 12 states, has approximately 300 employees, and generates annual sales of over \$60 million on deliveries of over 100,000 tons per year. Since restaurants are the dominant customers for carbonated soft drinks, recent growth in the number of restaurants, particularly fast food and franchises, has created a corresponding growth in the number of CO_2 customers. In addition to restaurants, movie theaters, hospitals, chemical manufacturers, and various other businesses are among the thousands of clients serviced each year.

Consolidation in the industry has created increased competition as other companies in the industry expand their product lines and geographical customer base. Our company wants to distinguish itself by superior customer service and low cost of distribution, both of which are also essential due to increased competition. As such, since labor costs for delivery are significant, the company focuses on creating efficient delivery schedules and distribution routes.

The company investigated serves most clients with delivery trucks that hold up to 8000 lbs of CO_2. Since most customers lease mini-bulk tanks with a capacity of anywhere between 200 and 600 lbs, a single delivery truck can serve multiple customers within a geographic region in sequence, only returning to the distribution center at the end of each day. The company's previous scheduling and routing procedure of delivery trucks relied on a manual system primarily administered by a single manager: every day, the manager would observe the average daily demand for each customer and schedule deliveries to those customers based on how close they were to stocking out. This would create a list of customers to be visited that day. The list would then be divided geographically among the drivers. Once the driver had a list of customers to visit, he would construct the route in consultation with the manager. Customers that were in most danger of stocking out on that day would be visited first, regardless of location. This type of system for deliveries caused the routes to be inefficient. As the number of customers and geographic dispersion in a region increased, the company found itself responding to more and more stockout emergencies. This practice began to impact financial performance and became a major concern for the company due to several reasons, which are discussed next.

First, labor costs for delivery drivers quickly grew as required overtime became a daily occurrence. Drivers are paid hourly and are hired to work four 10-hour days each week. One way to alleviate the problem would be to hire additional drivers for regular time wages. However, since all delivery trucks were already being utilized, adding additional drivers would also mean the purchase of another specialized delivery truck, requiring significant investment and ongoing operational costs. Another, less costly way to address the problem would be to create better routes, resulting in decreased driving time and thus overtime costs [4]. This latter approach is what we took in this project.

Second, drivers found themselves trying to determine routes between unfamiliar city combinations as reactive scheduling required emergency runs, even in the middle of a day's predetermined delivery route. Unfamiliarity with driving and traffic conditions, shortcuts, and customers increased overall driving and delivery times on each of the routes. O'Kane [5] described the difficulty of reactive scheduling, especially when decisions have to be made quickly and with limited experience and knowledge. While some of this impact is mitigated by learning, it still remains a significant problem given the number of customers and cities that each driver will visit.

Third, customers became disenchanted with the increasing frequency of stockouts. Generally, under VMI, stockouts are very expensive in terms of customer goodwill and can eventually lead to customers' sourcing from alternate vendors [6]. The majority of our company's customers, restaurants and movie theatres, depended on the availability of CO_2 for serving carbonated beverages, a major profit margin contributor. Although each customer is equipped with a 50 lb backup storage container, switching to the backup is a manual process that serves as an annoying reminder that their supplier is not performing adequately.

And fourth, irregular delivery schedules and poor driver–customer familiarity eroded the level of customer service and relationship management. Customers, who never know when their next delivery will occur or which driver will make the delivery, are understandably more anxious than customers who see a familiar face at regular intervals—especially when stockouts are a common occurrence. Choi and Hartley [7] substantiate this point by finding delivery and consistency the most important attributes for industrial buyers in selecting suppliers.