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An interventionist strategy for warehouse order picking: Evidence from two case studies

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ABSTRACT

As the role of the customer becomes more important in modern logistics, warehouses are required to improve their response to customer orders. To meet the responsiveness expected by customers, warehouses need to shorten completion times. In this paper, we introduce an interventionist order picking strategy that aims to improve the responsiveness of order picking systems. Unlike existing dynamic strategies, the proposed strategy allows a picker to be intervened during a pick cycle to consider new orders and operational disruptions. An interventionist strategy is compared against an existing dynamic picking strategy via a case study. We report benefits both in terms of order completion time and travel distance. This paper also introduces a set of system requirements for deploying an interventionist strategy based on a further case study.

1. Introduction

With the emergence of business to consumer (B2C) e-commerce, the role of the customer in modern logistics has dramatically changed (Ramanathan et al., 2014; Manzini et al., 2015b; Yu et al., 2016; McFarlane et al., 2016). Customers increasingly desire to place orders at any hour and to have them delivered at a time convenient to them (De Koster et al., 2007; Lam et al., 2015). As a result, the time available for processing and delivering an order is shortening (Gong and De Koster, 2008; Zhang et al., 2016). In addition to placing orders, customers may legally cancel their orders after placing it (Gong and De Koster, 2008). Moreover, a growing number of companies are offering the option to change the delivery time or location (Amazon, 2015b; Tesco, 2015). Hence warehousing systems must be capable of dealing with an increasing number of disturbances. In a business to business (B2B) environment, changes in production philosophies are now leading manufacturers to use smaller batch sizes, produce more customised products, and attempt to reduce cycle times as much as possible (Davarzani and Norrman, 2015; Lam et al., 2015; De Koster et al., 2007). This has led to a larger product variety and contributed to warehouses' need for shorter response times (Li et al., 2017; Gu et al., 2007; Chew and Tang, 1999; Otto and Chung, 2000).

It is, therefore, apparent that improving the response time to customer orders, be it in a B2B or a B2C context, is critical (Van Nieuwenhuyse and De Koster, 2009; Li et al., 2017). Furthermore, the unpredictable and changing nature of customer orders drives the need for modern warehousing systems' responsiveness. To achieve this, warehouses must improve order completion times, should they wish to meet the responsiveness expected by customers (Dekker et al., 2004), especially now that same-day delivery is one of the targets for businesses (Amazon, 2015a; Argos, 2015).

Among warehouse activities, order picking is the most labour-intensive and time-consuming one, especially within manual warehouses (Dekker et al., 2004; Bartholdi and Hackman, 2010; Manzini et al., 2015b). As a consequence, reducing the time needed for order picking can be critical for improving responsiveness in a warehouse. Making order picking less laborious is also important to improving efficiency (Ho et al., 2008; Thomas and Meller, 2015). A number of articles have reported that it accounts for as much as 55% (De Koster et al., 2007; Tompkins et al., 2010), 50–65% (Ma and Zhao, 2014), 60–65% (Henn, 2012), or even 60–70% (Chen et al., 2015) of warehousing costs.

Motivated by this, in this paper we introduce a so-called *interventionist order picking strategy* that aims to improve the responsiveness of warehouses by minimising the average order completion time (completion time - arrival time). The key idea behind such an "interventionist" strategy is that an order picking system could potentially perform better if it could be intervened by new orders arriving during the order picking process. We use the term 'order picking strategy' to refer to a set of key decisions associated with order picking, i.e. batching, pick-list realising and routing (De Koster et al., 2007). The interventionist order picking strategy is compared against a static strategy as well as against an existing dynamic picking strategy. The strategy is also tested in a trial that aims to identify the key

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requirements of a system deploying it in practice.

We focus on manual picker-to-part order picking systems as they are the most common systems worldwide (Gong and De Koster, 2008; De Koster et al., 2007; Battini et al., In press) and are likely to remain so for some time. Manual systems have been reported to reach adoption levels of 80% in the industry (De Koster et al., 2007; Napolitano, 2012). Although automating the order picking operation is feasible with today's technology, firms often choose manual solutions due to their lower cost and greater flexibility (Grosse et al., 2015; Elbert et al., In press), leaving aside the risks associated with manual operations (Grosse et al., In press). Indeed a very recent industrial survey indicated that only 3% of the respondents use automated picking systems while 60% still perform traditional paper-based manual picking (Michel, 2016).

The remainder of this paper is structured as follows. In Section 2 we review existing strategies to dynamic order picking. In Section 3, we introduce an interventionist order picking strategy which we then examine in two case studies in Section 4. We conclude with a discussion of the results and future research.

2. Background

In this section we review warehouse order picking operations in general as well as the dynamic strategies proposed for managing them. We conclude by presenting a set of limitations of existing dynamic picking strategies.

2.1. Order picking

Order picking is the process of retrieving a stock-keeping unit from its storage location in a warehouse (Petersen and Schmenner, 1999; Roodbergen and De Koster, 2001; Grosse and Glock, 2015). The order-picking system that controls the order picking operation, can be categorised into two types (Koo, 2008):

- Picker-to-parts system, where the picker travels (walks or drives) along the aisles to the allocated storage locations to retrieve the requested items. Such systems can be either manual or automated depending on whether the system employs humans or machines respectively as the pickers (De Koster et al., 2007).
- Parts-to-picker system, where the requested items are retrieved in an unit load (e.g. pallet or bin) and brought to a pick position (e.g. a depot) for a picker to take the required number of pieces, and after which the remaining load is stored again. Such systems are automated as they employ automated storage and retrieval machines (Manzini et al., 2015b).

In order to maximise the service level provided by order picking systems, researchers have mainly taken two approaches (De Koster et al., 2007; Gu et al., 2010):

1. *Storage optimisation (for picking)*: optimise the way items are stored so that can be easily and quickly retrieved during picking. This is often done via assigning different zones in a warehouse or deciding on specific storage locations of incoming goods (De Koster et al., 2007). Recent research in this area has focused on storing systems capable of handling dynamic and fluctuating demand (Manzini et al., 2015a; Tsamis et al., 2015; Li et al., 2016; Diaz, 2016).
2. *Picking optimisation*: optimise the order picking operation itself by batching orders together in pick lists, by routing pickers in a warehouse, by deciding when and how sorting will take place and by choosing the appropriate picking system (Davarzani and Norrman, 2015). Recent work in this area has focused in dynamic approaches for order picking (see below), the usage of metaheuristics for complex batching problems (Henn, 2012; Pan et al., 2015; Mutingi and Mbohwa, 2017), the impact of the human factor (Grosse and Glock, 2015; Vries et al., 2016), the joint optimisation of batching and routing (Li et al., 2017), and the performance of different automation technologies (Hong et al., 2016; Bortolini et al., In press; Lamballais et al., 2017).

In this study we focus on the second approach. Depending on the availability of order information, existing studies on order picking generally focus on either a deterministic or a stochastic setting (Van Nieuwenhuyse and De Koster, 2009; Gong and de Koster, 2011; Henn, 2012; Xu et al., 2014). In a deterministic setting, warehouse operations are assumed to use information that is known at the beginning of the planning period (Henn, 2012). Several static models and algorithms have been developed for problems in a deterministic setting (e.g. (Ratliff and Rosenthal, 1983; Elsayed et al., 1993; Van den Berg et al., 1998)), which assume perfect information availability about the objective function, and use this information to determine the search direction (Gong and de Koster, 2011).

In a stochastic setting, warehouses receive highly variable information throughout their operations. For example, with respect to customer orders, no information is known in advance about the actual content, size, or the arrival time of an order (Gong and De Koster, 2008). Stochastic settings are more realistic in practice (Van Nieuwenhuyse and De Koster, 2009). Even in a stochastic setting, deterministic models can still provide a good approximation in stable business settings (Gong and de Koster, 2011). However, static, deterministic models may become insufficient or even lead to wrong conclusions in highly uncertain environments such as in systems with strongly fluctuating order patterns and responsive operations (Gong and de Koster, 2011). Hence dynamic strategies are proposed and developed which provide a means of coping with systems that are stochastic, unstable, or inappropriate for deterministic methods. We will review these strategies next.

2.2. Dynamic strategies in order picking

A number of dynamic strategies have been suggested for managing warehouse orders in stochastic settings. These strategies generally aim to minimise the time any one order stays in a picking system, referred to as *order completion time*, *turnover time*, *throughput time* or *response time* (Henn et al., 2012). An overview of this strategies, with example references, is given in Fig. 1.

2.2.1. Dynamic order batching

Most studies focus on dynamic variations in order batching as opposed to varying the execution of the picking process itself. Order batching is the problem of determining the number of orders to be picked together in one picking tour (Le-Duc and De Koster, 2007; De Koster et al., 2007). More specifically, order batching concerns the partitioning of orders according to time windows or among workers to minimise travel distance (Gu et al., 2007). In static (offline) batching, customer orders are known at the beginning of the (short-term)

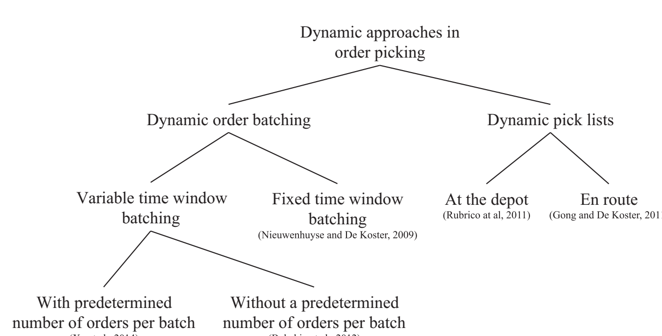

Fig. 1. An overview of dynamic strategies in order picking.