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ANALYZING THE MAIN AND FIRST ORDER EFFECTS OF OPERATIONAL POLICIES ON THE WAREHOUSE PRODUCTIVITY

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ABSTRACT

Using SIMIO™ simulation modeling framework, the main and first order effects of warehouse operational policies on the pallet order consolidation productivity is analyzed. The internal warehouse processes and functions are modeled by means of the discrete-event approach, while the unit-load automated guided vehicles are modeled by means of agents. The input data are based on 1,047 real customer orders. The warehouse storage area is modeled with a capacity of 10,080 pallet positions. Because this model is intended to support the design of a novel warehouse, it is validated following the parameters variability-sensitivity analysis. Then an exhaustive series of simulation experiments are conducted varying the number of AGVs, the AGV's load/unload time and the worker's picking-time. The scenario analysis indicates that the maximum hourly productivity of 394 picks per worker is obtained via 10 workers, 8 AGVs, AGV's pallet-load time of 6 seconds, and worker's picking-time distributed uniformly in 5-10 seconds.

1 INTRODUCTION

Logistics, as the backbone of international trade, encompasses freight transportation, warehousing, border clearance, payment systems, and many other functions (Arvis et al. 2012). Warehouses provide a place to store a buffer against unreliable demand or price, letting consolidate products to reduce transportation cost and to provide customer service (Bartholdi and Hackman 2011a). Particularly, order picking has long been identified as the most labor-intensive (Bartholdi and Hackman 2011b) and costly activity for almost every warehouse (De Koster et al. 2006). Managing the order picking process requires the organization of the orders to be picked and of the material handling operations of the picking (Gu et al. 2007).

2 MODELING AND SIMULATION APPROACH

The layout of the warehouse under study includes the storage area, the temporal storage area, and the withdrawal area. The storage area capacity is 10,080 pallet positions. The input of the simulation model consists in clusters of customer orders obtained by means of an external optimization process not described here. The operations modeled are: *clustering and scheduling* of 1,047 customer orders, the *assigning* of storage locations of 9,200 products, the *picking* of products by Automatic Guided Vehicles

(AGVs), and the *disposal* of the picked articles by ten workers. An intermediary database retrieves all the data required about the customer orders from a corporative database. This information is used to built clusters and sub-clusters, minimizing the number of AGV's tours along the warehouse. The optimizer output data are sent to another intermediary database to be available to the simulator. Then the simulator uses this information to create the data tables that are used as the simulation model input data. The simulation model output data are collected and post-processed, and the final results are presented to experts. The final results also feedback to the optimizer (Fig. 1).

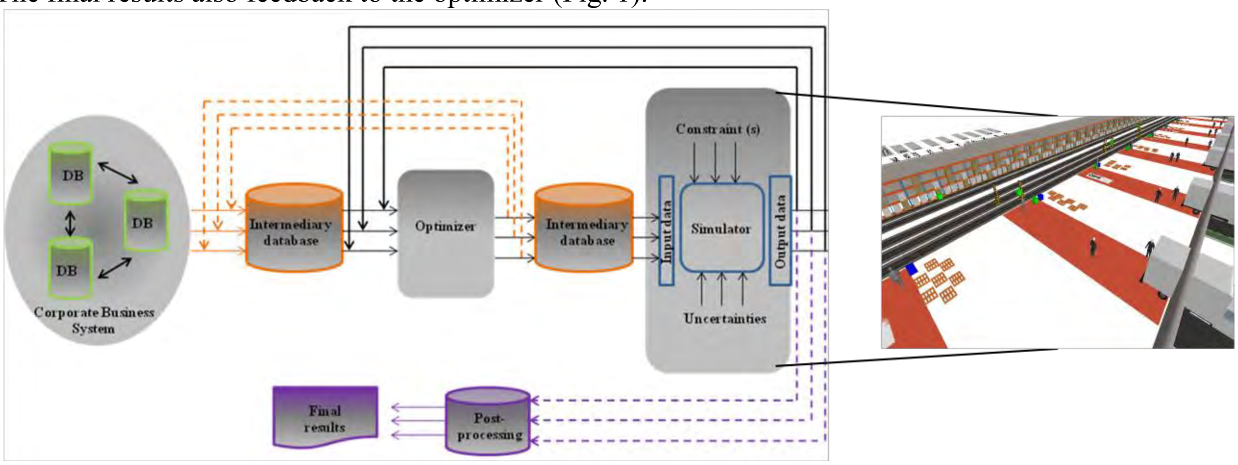

Figure 1: The simulation model architecture

We propose a 2^4 factorial design to conduct simulation experiments varying four factors in two value levels, resulting in the execution of sixteen different scenarios. The design factors are AGV´s load/unload time, number of AGVs and worker's picking-time. The scenario analysis indicates that the maximum hourly productivity of 394 picks per worker is obtained with 10 workers, 8 AGVs, AGV's pallet-load time of 6 seconds, and worker's picking-time distributed uniformly in 5-10 seconds. On the other hand, the analysis of the first order effects of design factors on the warehouse productivity suggests that there is a bottle neck that correspond to AGV's driving time. In conclusion, we believe that our study demonstrates how the mean warehouse productivity can be impacted by changes in the configuration of four of the most important warehouse resources, providing deeper insights for warehouse decision-makers, academics and practitioners. The relevance of this simulation study is the use of real data and the development of a hybrid simulation model using the software SIMIO™.

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