Scheduling Multiple Agents for Picking Products in a Warehouse
(Prof. J. Ota)

The picking problem is a complex, NP-Hard problem wherein orders from a warehouse must be efficiently picked by agents that begin and end their picking sequences (trips/routes) from a common shed. The objectives are to minimize the total number of trips the agents make and the total operation time (makespan). We have proposed to breakdown the picking problem into sequential stages to reduce its overall complexity as shown in Fig.1. The Route Generation (RG) stage creates a set of trips from the orders made on the warehouse – it does this with the aim of minimizing both the number of trips and the total distance covered by the trips. The Route Assignment (RA) stage then assigns the generated trips to a given number of agents that are tasked with picking the products. The aim of RA is to assign the trips such that there is maximal equity of tasks among the agents, i.e. it tries to minimize the difference between the longest and shortest operation times. By ensuring load balancing, the maximum agent operation time is also minimized. The final Dispatching stage, which is our main interest here, is concerned with a) the sequence in which agents are dispatched one after the other and b) the order by which routes assigned to a given agent are traversed. We formulate a model for the dispatching problem and show that it has a non-polynomial complexity with respect to the number of agents and number of routes. We then propose an effective simulation-based scheduling procedure to solve the problem with the aim of reducing agent interactions such as collisions or queues. We simulate a real warehouse environment (Fig.2) and show that the said dispatching procedure is able to keep delays caused by collisions and queues significantly low, and that it makes large improvements over the case when no dispatching policy is applied to the agents (Fig.3).

Keywords: multiple-agents, routing, warehouse automation, scheduling

References

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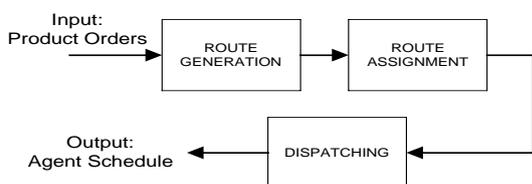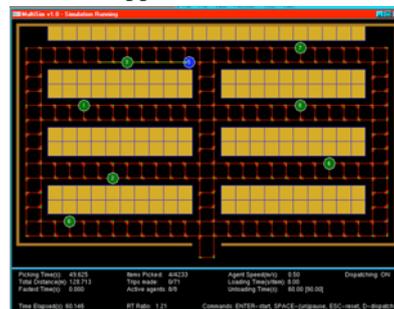
Fig. 1 Multistage solution to the picking problem

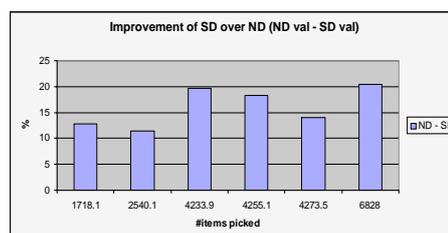Fig. 2 Simulation software for the warehouse picking problem

Fig. 3 Improvements gained from the dispatching procedure