A Dial-a-Ride problem in the internal logistics of a wafer fab

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ABSTRACT

We seek for a heuristic solution of an internal logistics problem arising in an industrial plant. The goal is to optimize pickup and delivery requests in a wafer fab where parts are transferred along a line. The problem at hand is a special Dial-a-Ride Problem (DARP) with a 1-dimensional geometry. A mixed integer linear program (MILP) is proposed within a two-phase math-heuristic method. In the first phase, we solve a MILP in order to assign requests to cart routes (spans). Then, we solve a Bottleneck Assignment problem to assign spans to carts, simultaneously scheduling each cart moves. Integer programs are solved via a state-of-the-art solver. Good quality heuristic solutions are in this way found in a CPU time compatible with the company operational constraints.

KEYWORDS

Dial-a-Ride Problem, Mixed Integer Linear Programming, Bottleneck Assignment problem, Heuristic method.

1 Introduction

The Dial-a-Ride Problem (DARP) calls for designing vehicle routes and schedules for m users who specify pickup and delivery requests involving n possible sites [1]. In our case, we wish to minimize the largest completion time of the requests, and to this aim we try to exploit the linear structure of the problem, showed in Figure 1 and not much considered in the literature.

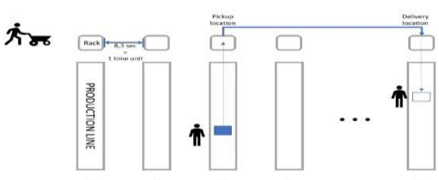

Figure 1: Scheme of the company production line

2 The model

Forward and backward requests form a finite set $R = R_F \cup R_B$ of directed arcs with extremes in n possible positions. Positions are extremes of $O(n^2)$ intervals, called spans, that define possible routes. Instead of assigning each request r to a cart k, we first assign requests to spans, then find an appropriate matching between spans and carts.

2.1 Request-to-span allocation

Let S denote the set of all possible spans that it is sensible to consider (it is in fact enough to list spans that are minimal with respect to the assignable requests). Let x_{rs}= 1 if request r is assigned to span s, and 0 otherwise. Each request must be assigned to some span. Moreover, with p available carts, we must ensure that each span chosen matches one cart; this is controlled by activation variables y_s, y_{sB}, y_{sF} that indicate that span s is respectively used by some (backward or forward) request: the variables introduced must then fulfil p-median-like constraints

$$x_{rs} \leq y_{sF} \leq y_s \ (r \in R_F), \quad x_{rs} \leq y_{sB} \leq y_s \ (r \in R_B), \quad \textstyle\sum_s y_s = p$$

As in this phase spans are not yet associated with carts, travel time is just estimated via the span length t_s and the number of pick-up and delivery requests assigned to it; under this assumption we then minimize via MILP the time C_{max} to cover all the requests in R with p spans.

2.2 Cart-to-span matching

Once requests have been assigned to spans via an optimal MILP solution, we must match the p carts available to the p spans found, and simultaneously schedule cart operations. A solution is therefore a perfect matching where, in view of our min-max objective, we minimize the largest cost of an assignment. Serving with cart k the requests of a chosen span s requires the time to reach the point of s which is closest to its current position plus the necessary time C_s to schedule the requests associated. Since for the moment we can assume unbounded cart capacity, scheduling a cart can be done in linear time. As before, we minimize the total completion time C_{max}, which now amounts to solve a Bottleneck Matching problem.

3 Conclusion and future study

In this paper, we proposed an application of a Dial-A-Ride Problem (DARP) to the internal logistics of a wafer fab. The problem is solved by an original math-heuristic in CPU time compliant with fab operation, and solutions appear of good quality. We aim at measuring optimality gaps by comparison with optimal solutions found via integer programming. Further development will focus on finite cart or buffer capacities.

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REFERENCES

[1] Cordeau J, Laporte G (2007). The dial-a-ride problem: models and algorithms. Springer Science Business Media, LLC. 153: 29-46.