Linear programming in receding horizon model based manufacturing control

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1 Introduction

Industrial complexity increases with product complexity and vice versa. The need for more intelligent, higher level control becomes stronger. Although manufacturing systems are often characterized as discrete event systems, in a real physical plant time evolves and events occur in time.
In this research, we use linear programming (LP) to schedule jobs (in time) in a manufacturing system. The method uses a receding horizon principle and is dynamic in a way that it deals with perturbations by online re-invocation of the optimization procedure.

2 The method

The dynamic behavior (product recipes and routings, process times, machine and buffer capacities) of a discrete event manufacturing system is translated into a LP problem. Assumptions that have to be made include:

- Product routes and recipes are deterministic.
- For the LP problem, process times are constant and include setup times.
- Transportation takes no time.
- In the LP problem, machine failures or breakdowns are not accounted for.

Design variables of the LP problem are the time instances products enter the system or arrive at buffers and machines. The production policy is put into the objective function of the LP problem and, if necessary, additional constraints. Conventional production policies, like push, pull and conwip, can be applied. The initial state of the manufacturing system (buffer levels, remaining process times on machines) is taken into account by means of the constraints.
The control/optimization method uses a receding horizon. The optimization procedure can be invoked in different ways:

- Optimize over a fixed number of products that has to be processed.
- Optimize over a fixed time span.
- Optimize over a weighted combination of products and time.

In addition to these regular optimization re-invocations, the optimization routine can be invoked on any irregular event, such as machine breakdown or exceptional process times.

3 Example

Consider the manufacturing system of Figure 1 consisting of a generator G, infinite buffer B, machines M_1 and M_2, finite buffer $B(2)$, batch machine F and exit E (stock). The process times of the machines are 2, 3 and 3 time units respectively and the batch size equals 2. Products have recipes as indicated in the figure. The buffers B and $B(2)$ send to and receive from machines M_1 and M_2 alternately. In Figure 2 the results are plotted for an optimization with product due dates $\{6,7,9,9,13,14\}$, penalty on tardiness and just-in-time policy.

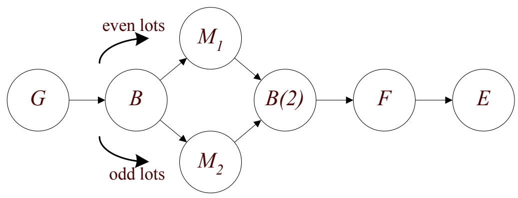

Figure 1: Manufacturing system configuration.

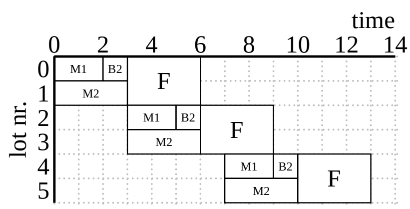

Figure 2: Lot-time diagram.

4 Conclusion

Linear programming can be used in manufacturing control. Different control policies and initial (non empty) states of the system can be implemented. To control systems with stochastic process times or breakdowns, a feedback-like receding horizon method can be used.