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A SIMULATION FRAMEWORK FOR CLEARING FUNCTION-BASED RELEASE DATE OPTIMIZATION IN A MATERIAL REQUIREMENTS PLANNING PLANNED PRODUCTION SYSTEM

Wolfgang Seiringer

Department for Production and
Operation Management
University of Applied Science Upper Austria
Wehrgrabengasse 1-3
A-4400, Steyr, AUSTRIA

ABSTRACT

In this research work a simulation framework is developed helping to overcome the missing capacity limitation of material requirements planning (MRP) to obtain more reliable planning results. Therefore, the concept of clearing functions (CF) are integrated as constraints into a mathematical optimization problem. When using CF as capacity constraints it is possible to identify how much of the current workload is realistic to be processed on the shop floor of a production. The CF based release dates will replace the fixed planned lead time of MRP, which is unable to handle capacity limitations. To evaluate the performance of CF based release date planning a comparison with standard MRP using a simulation experiment is done. First results show the potential of the CF approach, but due to the complexity of the release mechanism adjustments to the planning and optimization component in the simulation are necessary.

1 INTRODUCTION

The widely applied medium-term planning approach of Material Requirements Planning (MRP) neglects the limitation of production resources. Independent from this limitation MRP has proven to be a simple and expandable approach for computing the production schedule. Nowadays manufacturing companies must operate their production in an increasing dynamic environment expressed by economic disruptions in the last years like supply chain disruptions and the energy crisis. Outcome entailed disruptions in the supply chain, leading to fluctuations in capacity that cannot be effectively managed using conventional MRP methods. One of the factors preventing MRP from predicting capacity fluctuations is its reliance on a deterministic planned lead time for calculating the production schedule. Deterministic lead times do not represent the actual shop floor situation as process variability, change over and setups are not depicted. Manufacturers strive for a high customer service level. To maintain a good customer service level the usage of overestimated lead times may be fine, but this also increases the inventory holding costs. Underestimated lead times, in contrast, can increase the queue before machines which will increase, when demanded capacity is higher than provided capacity and unplanned downtimes occur. To find a near to optimal lead time effects on inventory and utilization must be investigated. In this context, the concept of Clearing functions (CF) is a suitable approach. CFs are considering the nonlinear relationship between workload and output in a planning period and capture the fact that cycle times are a nonlinear function of utilization. Cycle times represent the delay between work being released into the production system and its emergence as finished product. One can argue to use cycle times as substitute for lead times for MRP backward scheduling. As the output of a CF does not produce a lead time directly this is not a straightforward process. Independent of this complexity, CFs are a suitable concept which can be applied in the context of MRP to compute planned order releases with a more realistic representation of the shop floor situation.

Based on the described issues, the objective of this research work is to compare the integrated optimization-based release planning (including CF) with standard MRP using a discrete-event simulation framework. The leading research questions focuses on: "*How high is the improvement using CF optimized release date planning compared to standard MRP with fixed planned lead times?*"
The following section describes the simulation framework components for CF integration in the context of an MRP planned production system and afterwards the status of this research work is described.

2 SIMULATION FRAMEWORK FOR OPTIMIZED RELEASE DATE PLANNING

In this research work CFs support the computation of mathematically optimized release dates for the planned order releases as a substitute for the time phasing step (backward scheduling) of the MRP procedure, compare to Figure 1. When backward scheduling is applied fixed planned lead times are used to set the start date of the planned order releases. The objective of the optimization problem is to minimize the sum of inventory, WIP and backorder costs in combination with CFs as capacity constraints. After the lot sizing step, a choice must be made: either proceed with the standard MRP using a fixed planned lead time, or utilize the CF based version. This version involves solving a production planning model framed as an optimization problem, incorporating CF as a capacity constraint. When using the CF based version a workload-based CF for each machine is used to identify how much of the workload can be processed with the available capacity per period (day). CFs are used as capacity constraint for the optimization problem.

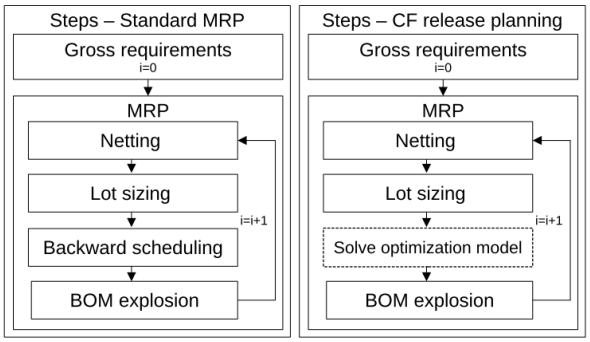

Figure 1: Steps MRP vs. CF release planning

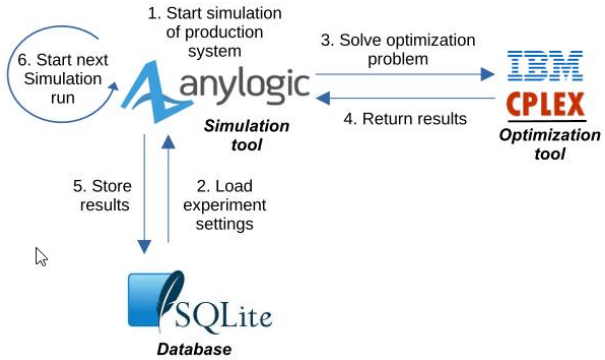

Figure 2: Simulation and optimization interaction

To facilitate the described planning behavior the discrete event-simulation framework if Figure 2 was developed. After simulation start (step 1) in step 2 the scenario and planning parameters are obtained from the database. If standard MRP is applied, a cplex solver call is not necessary, as MRP is implemented as algorithm in the simulation framework. When using CF release planning then the obtained optimization model is passed every period (day) to the cplex sover (step 3) and the simulation waits until the solution from the optimization problem is available and returns the results for the subsequent shop floor processing (step 4). After the end of the simulation run time the cost and production related results e.g. tardiness, service level and inventory are stored in the database (step 5). If the current simulation involves parameter variation and other parameters still need simulation, initiate the subsequent simulation run (step 6).

3 CURRENT STATUS AND OUTLOOK

The implemented simulation framework using Anylogic can simulate an arbitrary multi-item multi-stage production system using MRP or CF based release date optimization. During first performance evaluations a problem regarding the correctness of the solved CF based optimization problem was identified. Having a solution for this issue a simulation study can be performed to evaluate CF integration during MRP planning. With respect to the current progress the plan is to disseminate the results in a journal within the next 6 to 9 months.