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Production Scheduling & ERP Systems: Towards Seamless Integration

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During the second half of the 20th century, an increasing interest in production scheduling was recorded. The transition from simplistic inventory control models to MRP signaled an incessant computerization of production activities but it was not until the introduction of MRPII in early 80's that production scheduling became an inextricable function of such systems. MRPII extended the basic functionality of MRP (which focused on material requirements) and for the first time, dealt with capacity, resource allocation and shop floor control. Some years later, ERP (Enterprise Resource Planning) systems emerged from legacy MRP and MPRII manufacturing systems and they since constitute an integrated enterprise information system that automates the flow of material, information and financial resources among all functions within an enterprise using a common database.

ERP is the direct descendant of MRP II (Turbide, 1999). The term was suggested by Gartner group which specified that ERP is actually an MRP II system with added coverage in areas like marketing support and after-sales service. In fact, as Turbide (1999) states, ERP is not that different from MRP II but it was chosen to characterise a rapidly growing MRP system beyond anyone's expectations.

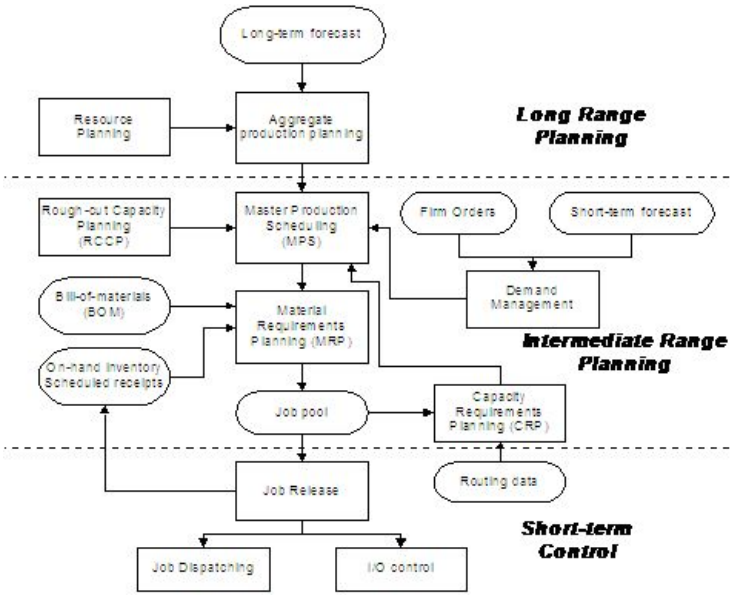

Figure 1. Closed-loop MRPII schema. The core production functionality of ERP systems

Embedded functionality of modern ERP systems

Nowadays, production activity could be characterised as chaotic. More complex product structures, higher production volumes, larger product diversity and customization, shorter product lifespan and finally shorter production and delivery lead times are just a few aspects (Hopp and Spearman, 1996). Even modern ERP systems, which constitute an excellent platform to monitor and control all enterprise operations, do not always manage to tackle effectively production scheduling problems. Such problems are usually very complex and require the development of specialized solution methodologies which although they can be implemented in an ERP system, they cannot cope with all possible production environments.

Even the most advanced systems perform primitive resource capacity checking with limited abilities to cope with potential overloads. In most cases, in an effort to avoid such detrimental overloads, very high resource idle times are introduced that in turn lead to production delays. Therefore, the resulting schedule is far from the optimal one. Even worse, very few ERP systems incorporate mechanisms to confront potential infeasibilities and thus, they are limited to just reporting such conditions. It should be mentioned that even the most advanced ERP packages, only have basic functionalities towards this direction.

The culprit for ERP's inefficiency

According to Dauzere-Peres and Lasserre (1994), it is remarkable that in both academic literature and industrial practice, mid-term planning and scheduling issues are treated in sequence and independently of each other. This issue is also cited in Lenstra et al. (1984). In most cases, the production planning/scheduling procedure is performed sequentially with the production schedule following a production plan. This type of approach can be viewed as a one-pass procedure where the planning level has a very aggregate level of view of the workshop. The difficulty in integrating planning and scheduling is that planning is a continuous process while scheduling is discrete (Dauzère-Pères and Lasserre, 1994). However, production planning optimization should not be performed independently from scheduling.

Another culprit for ERPs inefficiency considering production scheduling is the great diversity of all possible production environments. This fact necessitates the development of an optimization algorithm specific to each production environment which in turn increases development cost and time to profitless levels.

A seamless integration schema

Efficient production scheduling within ERP systems should be based on the joint optimization of production planning and scheduling and the customization of the scheduling algorithms to suit the specific production environments.

At the production planning level (usually ranging from 2 weeks to 6 months), a metaheuristic algorithm (Blum and Roli, 2003) generates a feasible plan by taking into account capacity constraints and penalizes the earlier delivery or delay of a production order (Zobolas, 2008). This is performed by altering the Master Production Schedule (MPS) to balance all contradicting aims: idle times, delays, early deliveries, resource overloads, overtime and resource utilization. The problem is that the application of any metaheuristic method at this stage does not ensure the feasibility of the resulting schedules at the more detailed scheduling level (usually daily and less often weekly).

The idea behind the proposed scheme is to apply an advanced shop type metaheuristic algorithm to the resulting scheduling problems, one for each time bucket of the system (as mentioned, usually daily). A group-shop or mixed-shop metaheuristic algorithm (Masuda, 1985) is generally flexible enough to cope with most manufacturing environments as it can be easily converted to either a job-shop, flow-shop or open-shop algorithm. More specifically, the function of this algorithm is to optimally arrange the jobs belonging to the job-pool (see Fig. 1) of the optimized production plan of the previous level targeting at the minimization of the makespan (maximum completion time of all jobs). If the optimized schedule exceeds the available time (as expressed by working shifts) the production schedule for the specific bucket and, in extension, the corresponding production plan are both infeasible. The user is then prompted to modify the job-pool or the production plan.

Conclusion and Areas of Further Research

Undoubtedly, ERP systems are becoming increasingly necessary for modern enterprises. Despite their undeniable evolution the last ten years, they still often fail to provide a solid basis for efficient and accurate production planning and scheduling. The reasons behind this are mainly the discontiguous development of production plans and schedules and the great diversity of possible manufacturing environments which involves the (high cost) development of an optimization algorithm exclusively for each environment.

Thus, production planning and scheduling should be closely linked. The production plan (at the MPS level) should be first optimized by a metaheuristic algorithm followed by a detailed

evaluation of the resulting schedules by a second flexible metaheuristic algorithm. In terms of further research, a special routine should be developed to automatically readjust production schedules and/or plans in case of schedule infeasibility. This is the final step of ERP and scheduling integration which if achieved, will signal a new era for production planning and control.

References

Blum, C. and Roli, A. (2003) Metaheuristics in Combinatorial Optimization: Overview and Conceptual Comparison, *ACM Computing Surveys*, v35, 268-308

Dauzère-Pérès, S. and Lasserre, J.-B. (1994) *An integrated approach in Production Planning and Scheduling*, Springer-Verlag

Hopp, W.J. and Spearman, M. L. (1996) *Factory Physics: Foundations of Manufacturing Management*, Irwin

Lenstra J.K., Rinnoy Kan, A.H.G., Brucker, P. (1984) New directions in scheduling theory. *Operational Research Letters*, v6, 255-59

Masuda, T., Ishii, H. and Nishida, T. (1985) The mixed shop scheduling problem, *Discrete Applied Mathematics*, v11, 175-86

Turbide, D.A. (1999) What is ERP?, *Foundry Management & Technology*, v127, 94-98

Zobolas, G., Tarantilis, C.D. and Ioannou, G. (2008) Extending Capacity Planning by Positive Lead Times and Optional Overtime, Earliness and Tardiness for Effective Master Production Scheduling, *International Journal of Production Research*, v46, 3359-86