Trends in planning and control systems: APS – ERP integration

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Abstract

This paper focuses on the evolution of planning systems in the recent years. In particular it deals with APS (*Advanced Planning Systems*), showing which limitations of traditional information systems for production planning APS overcome and highlighting their technical potential.

Moreover, the issue of the integration between APS and ERP (*Enterprise Resource Planning*) is deepened. In particular the authors explain why the integration is necessary nowadays and give some useful guidelines for the design of APS-ERP integration.

Keywords

Advanced Planning System, Material Requirements Planning, Enterprise Resource Planning

1 INTRODUCTION*

This paper focuses on the production planning system design. In particular, it deals with an overview of the evolution of the demand and the offer of production planning systems and deepens the critical features of production planning systems design in today's manufacturing systems.

Planning and control systems have deeply evolved in the recent years in order to cope with the need of the manufacturing firms.

* This paper has its origin in the collaboration of the authors. In particular, in the final release M. Caridi has developed sections 1 and 3.1 and A. Sianesi sections 2 and 3.2.

In the Seventies, the key of success for manufacturing firms is cost: managers are concerned with industrial cost reduction and the support to planning and control is basically based on MRP (*Material Requirements Planning*), which (in theory) allows to manage production and assembly with low inventories and low work in progress. The support to scheduling is still not advanced: a rough plan, built through a simple Gantt of the manufacturing resources, is enough for managing the firm, since timeliness and punctuality are not critical for the response to the market.

Later in the Eighties, the market switches its attention to other performances of manufacturing systems: time, quality and service level become much more critical than costs. Generally speaking, firms are not prepared to cope with this new way of competing. Together with the redesign of the whole organisation and management, the support of information system to production and control changes: highly performing short-term production planning systems are now necessary, where the schedule of machines takes in fair account the limitation of capacity of productive and auxiliary resources. Consequently to the modification of the firm configuration, planning systems begin to support multi-site planning and suppliers.

In the Nineties the evolution has gone on. New functions, such as ATP (*Available to Promise*), are considered necessary conditions for a order planning and quoting. On the other hand, the offer of planning systems has reached a high level of performance with APS (*Advanced Planning System* or *Advanced Planning and Scheduling*), where huge sets of objectives and constraints are standardised in libraries so that manufacturing system can be modelled in detail.

Nowadays, the integration between APS and the ERP (*Enterprise Resource Planning*) systems represents an interesting topic that is getting more and more attention from the point of view of planning system designers.

The limitations of ERP systems as far as manufacturing is concerned are in fact well known. In order to cope with ERP's criticality in manufacturing, APS-ERP integration has to be designed.

Actually, this means defining a global APS-ERP project where many decisions have to be taken, as for the logic of locating data into the system (technical data have to be managed inside ERP or APS?) or the logic of locating functions which are present both in ERP and APS (medium-term planning runs in ERP or APS?). These are just an example of the problems that production planning designers face nowadays.

After a brief overview of the trends of IT support to production planning systems in the last years, the paper deepens the topic of APS-ERP integration and presents some guidelines for the design of this integration.

2 THE EVOLUTION OF PLANNING SYSTEMS

APS systems represent the most meaningful innovation in the world of manufacturing since the introduction of systems MRP in the Seventieth (Turbide, 1998). In fact they marry the potentialities of the modern processing systems with

the most sophisticated heuristic/optimising/AI-based techniques developed from the researchers in operations research and industrial production management (Caridi, Sianesi, 1999).

The first example of application of information system to the technical-manufacturing area is MRP that calculates the requirements of end products, sub-assemblies, components and raw materials starting from the medium-term production plan. Today MRP remains the backbone of the modern integrated ERP systems, since several applications (e.g. industrial accounting) are based on technical data of MRP (e.g. BOM, *Bill of Materials*, routings, etc.).

In the recent years competition has evolved towards shorter time to market, huge manufacturing mix, complex and customised products. In this new scenario of competition, MRP has shown all its structural limitations. These limitations are worth deepening since they are today one of the main obstacles to the introduction of ERP in a firm.

The hypotheses at the basis of MRP are: all the clients, products, materials have the same priority; lead times are known *a priori*; resource capacity is infinite; there are not predetermined sequences; planning horizon is covered by client orders or forecasts. These assumptions are obviously not verified in real manufacturing systems.

Moreover, MRP is a batch procedure which is heavy for the information system, since it processes a large volume of data (orders, forecasts, cycles, part database, warehouse balance, and so on). This limitation obstructs the interactive utilisation of MRP in a simulating way to test the reaction of requirements to face input variations (e.g. introduction of new orders, variation of lead times).

Probably, the main limitation of MRP is that it does not take into concurrent consideration the limitation of capacity and materials, so it frequently processes an unfeasible program and, in this case, it reports the critical points of the output so that the user can solve them.

Because of the evolution of competition, the above-stated MRP's limitations are no longer sustainable and firms have found an answer to their problems in APS.

APS represents a breakthrough in production planning since it overcomes two basic principles of MRP:

- *the way the plan is processed*: MRP systems and, in general, all the scheduling algorithms, based on heuristic or optimising techniques (Baker, 1974), propose a plan (*what* shall be produced, *how much*, *when*, *where*, *with which resources*) that the user has to validate. On the contrary, APS is a support to the decision-maker (it can be classified as DSS, *Decision Support System*). In fact, the aim of APS is not modelling accurately complex manufacturing systems or implementing refined resolution techniques. Rather, its aim is interactivity in finding the solution, efficiency in managing large volume of data, quantification of several proposed plans, speed of simulation;
- *the approach*: MRP systems and traditional scheduling systems are based on a centralised top-down approach. They assume, in fact, that only a decision-maker has the responsibility of determining the manufacturing plan. In other words, a single MRP processes all the items of the firm, starting from end

products down to raw materials or supplied items. As a consequence, constraints propagate along the levels of BOM. On the contrary, in the most advanced APS systems the degree of centralisation can be configured: by setting the parameters of the system, one can model highly centralised control or situations in which each shop (or even each machine) is a decision-maker that can plan its own activities. In the latter case, APS guarantees the alignment of the several plans. Moreover, in an APS also the direction of control is configurable: one can model a traditional top-down control but also a bottom-up control, where the decision of *what can be produced* is made starting from the availability of materials.

Then APS systems represent an evolution of traditional systems since they process plans which respect all the constraints of the problem (starting from resource capacity and materials availability and so on) and allow to carry out a *what-if* analysis.

Other features of APS overcome the limitations of traditional approaches from a technical point of view:

- *processing speed*: APS systems are RAM resident, so they can exploit the speed of execution of processes in memory. In order to exploit this potentiality, APS requires computers with huge memory. In this way, the efficiency of processing time increases very sensibly in comparison with MRP performance (processing time is reduced to few minutes from few hours);
- *support to the user*: since the user makes decisions, APS systems are endowed with advanced graphical interfaces; in fact the user needs to have immediate access to many information and data. As a consequence, when an APS is designed, particular care is given to the way information and data are visualised and to the possibility of choosing the level of aggregation of information on the screen;
- *optimisation module*: the most sophisticated APS systems contain several libraries of typologies (models) of manufacturing systems and of resolution algorithms. Moreover, since each manufacturing system has its own peculiar features, APS is endowed with programming languages to create routines *ad hoc*, combining different optimisation rules. Anyway, the aim of the optimisation module is to find not the *best* solution but a *first* solution, which can be examined and reprocessed by the user in order to reach a feasible solution which respects the availability of productive resources (e.g. manpower and machines) and auxiliary resources (e.g. transport systems, equipment, tools);
- *constraint representation*: since APS aims at finding feasible solutions, it is very important to define precisely the data of the problem, especially those related to the constraints. Then, it is necessary to monitor them on-line in order to refresh the status of the system. This point is so relevant that the resolution algorithms of the optimisation module are often based on constraint propagation (*Constraint Based Programming*).

3 APS-ERP INTEGRATION

3.1 Why is necessary APS-ERP integration?

In the previous section the evolution of production planning system has been illustrated and, in particular, the potential of APS has been deepened. Beside this evolution, in the recent years the integrated ERP systems have imposed themselves. These systems give support to the several functions of the firm, accounting, finance, marketing, logistics, production and so on. Since production requirements are covered by ERP, the usefulness of APS is questionable.

On the other hand, the evidence is that in many industrial applications ERP systems are integrated by the implementation of an APS. This choice usually leads great benefits to the firms, if the integration is well designed, defining the specific tasks of the two systems and the way data are distributed between them. This point is worth deepening.

ERP and APS systems show relevant differences, which are summarised in Table 1.

Recalling the limitations of traditional approaches to production planning described in Section 2, it is evident that the requirements of planning and control are better satisfied by an APS than an ERP, since APS allows simulations, detailed model of constraints and interactive plan processing. This is the reason way APS-ERP integration is necessary.

Table 1 Comparison between ERP and APS (source: Caridi, Sianesi, 1999)

	<i>ERP</i>	<i>APS</i>
Focus	Managing and integration of functional data, often through processing in batch	Analysis and simulation of shops or supply chains, often in real-time
Capacity	Infinite (or managed indirectly as finite through lead time setting)	Finite and detailed for each productive resource (e.g. manpower, machines) and auxiliary resources (e.g. equipment, tools)
Control	Hierarchical top-down	Distributed and, possibly, bottom-up
Logic of calculus	Simple (e.g. BOM explosion), automatic and repetitive	Heuristic/optimising /IA-based algorithms propose a first solution which is modified by the user

3.2 Guidelines to APS-ERP integration: the lessons learned

A few remarks follow about the way ERP-APS should be integrated. These remarks derive from the lesson learned by the authors from several industrial cases they have analysed.

The first consideration relates the criteria that guide the choice of placing data in APS system rather in ERP system. In fact, certain typologies of data are needed by both APS and ERP so that it is not obvious the decision of where they should be placed. The authors suggest classifying data according to their *visibility*:

- inter-operational stocks (balance and movements), master item file, BOMs and routings must have an *inter-functional visibility*, then they should be stored in ERP. APS can read these data (item data, BOMs, routings) as an input of its processing and can update them as an output (warehouses). The reason why they should be placed in ERP is that they must be “visible” also to other functional systems, for instance to the industrial and analytical accounting;
- set-up time, alternative of machines or of BOMs or of routings are exclusively used in production planning (*productive visibility*) so they should be placed in APS.

The second consideration regards the placement of the client order management system in APS or ERP. Traditionally, it does not regard APS since it does not regard production but when order management requires ATP functionality (that is the definition of the quantities of end products, which can be sold in a certain period), the previous sentence does not appear obvious as before. According to the authors, APS should support ATP functionality as a slave unit of ERP, providing information (e.g. availability of materials, planned manufacturing orders, slack of capacity and so on) which ERP processes in order to perform ATP.

These guidelines for ERP-APS integration should prevent from data duplication in APS and ERP.

Lastly we conclude observing that in large companies the integration APS-ERP usually involves an ERP and more than one APS, for example one for each production centre. ERP contains the functions that interface the market (e.g. marketing, logistics), which must be homogeneous in the different centres of the company. APS systems contain the logic of production planning, which can be different from production centre to production centre, so that company can decide to implement an APS per centre.

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5 BIOGRAPHY

Maria Caridi graduated at Politecnico di Milano, where she works as a researcher in Industrial Production Management. Her main interest is production planning and control: as for the techniques, she has been studying the application of Multi-Agent System theory to the control of manufacturing systems; as for the instruments, she is concerned in how modern APS systems cover manufacturing system requirements and how they can be effectively integrated with ERP systems.

Andrea Sianesi graduated at Politecnico di Milano, where he works as Associate Professor of Industrial Production Management. His main research topics are production planning and scheduling and information systems. In particular he deeply investigated MPS algorithms, BOM management and mixed model assembly lines scheduling problem. Recently he has focused his research on the integration of ERP and APS and on information systems supporting supply chain planning.