SCM-ERP integration: organisational, managerial and technological issues

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ABSTRACT:
This paper focuses on the latest evolution of information systems for Supply Chain Management. In particular, starting from the observation that Advanced Planning Systems and Supply Chain Management Systems represent a real breakthrough in IT support to Production Planning and Control, the paper briefly shows how IT support has evolved over time both at company level and at supply chain level and deepens the critical features of IT systems design for today's supply chain systems.

Keywords: Supply Chain, Enterprise Resource Planning, Production Planning and Scheduling.

INTRODUCTION

Planning and control systems have deeply evolved in the recent years in order to cope with the need of the manufacturing firms and new IT tools (named APS, *Advanced Planning Systems*, or SCM, *Supply Chain Management* systems) are nowadays available.

Contemporary the ERP (*Enterprise Resource Planning*) phenomenon has been consolidated, but the limitations of ERP systems, as far as manufacturing or distribution is concerned, are well known. In order to cope with ERP's criticality in supply chain, integration of ERP and SCM systems has to be designed.

Despite the great evolution of IT, the effort of the integration between SCM and ERP is still today impressive; so the authors explain why the integration is necessary and provide some guidelines for the design of SCM-ERP integration.[1]

IT IN MANUFACTURING: APS-SCM SYSTEMS

Planning and control systems have deeply evolved in the recent years in order to cope with the need of manufacturing firms. It's possible to identify a route of evolution that begins with the introduction of MRP systems (Orlicky, 1975) and, passing through the management of capacity and materials constraints, moves towards the contemporary APS and SCM solutions.

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

This is the era of APS-SCM solutions. APS-SCM 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 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).

APS-SCM 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-SCM is a support to the decision-maker (it can be classified as DSS, *Decision Support System*). In fact, the aim of APS-SCM is not to model accurately complex manufacturing systems or to implement refined resolution

[1] This paper has its origin in the collaboration of the authors. In particular, in the final release M. Caridi has developed sections 2, 4 and A. Sianesi sections 1, 3.

techniques. Rather, its aim is interactivity in finding 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-SCM 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-SCM guarantees the alignment of several plans. Moreover, in an APS-SCM 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-SCM 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-SCM overcome the limitations of traditional approaches from a technical point of view:

- *processing speed*: APS-SCM systems are RAM resident, so they can exploit the speed of execution of processes in memory. In order to exploit this potentiality, APS-SCM 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-SCM 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-SCM 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-SCM 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-SCM 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-SCM aims at finding feasible solutions, it is very important to define precisely the data of the problem, especially those related to constrains. 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*).

ERP-APS/SCM INTEGRATION

During these recent years the most glaring phenomenon of manufacturing IT's market has been the diffusion of ERPs solutions. Several causes have favoured this phenomenon:

- the well known Y2K problem, that moved several companies to rebuild their information system, adopting, where possible, standard solutions with the aim to reduce project's elapsed time;
- the success of some competitors that have polarised the whole ERP market that today (in Europe) is mainly on few international solutions
- the need to ensure a deeper economical and managerial control as the consequence of globalisation efforts
- the wide range of functionality encompassed into an ERP solution, allowing to satisfy especially the finance and accounting requirements;

It is evident that the above mentioned factors have been much more strong that the requirements in terms of supply-chain optimisation; the proof of this sentence is the fact that nowadays most companies have an ERP solutions, while, on the contrary, the diffusion of APS-SCM solution is at an embryonic stage. Indeed from a market perspective the evolution of APS-SCM markets directly follows ERP's one; several empirical proofs of this can be found analysing market trend; for sake of simplicity we mention here a sentence of (Turbide, 1998) "*…the first APS-SCM systems were third-party solutions that had to be connected to ERP. This made APS implementation both complex and expensive. With the maturation of the technology and increased market recognition of the value of APS, a consolidation began. First, major ERP vendors formed alliances with APS vendors offering some level of pre-packaged integration. Now, several ERP suppliers have acquired APS developers and are in the process of integrating the systems together for a seamless, fully integrated ERP/APS solution. A few ERP vendors have developed their own APS capabilities…*"

It's easy to identify the ERP + APS-SCM as the more satisfying architectural solution for Supply Chain Management and Control.

The following figures summarise the evolution of IT tools:

- Figure 1 shows the evolution, at a "general" level, from "Make" solutions to ERP-APS, passing through Best-Of-Breed and "only-ERP" solutions;
- Figure 2 zooms in the Supply Chain level, showing the moving from ERP till to ERP-SCM integrated systems.

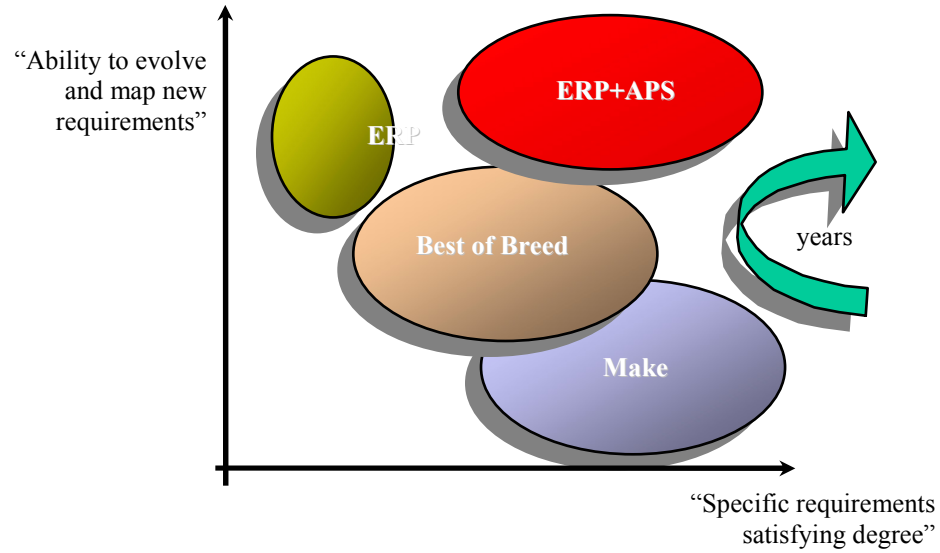

Figure 1: IT evolution at a company level

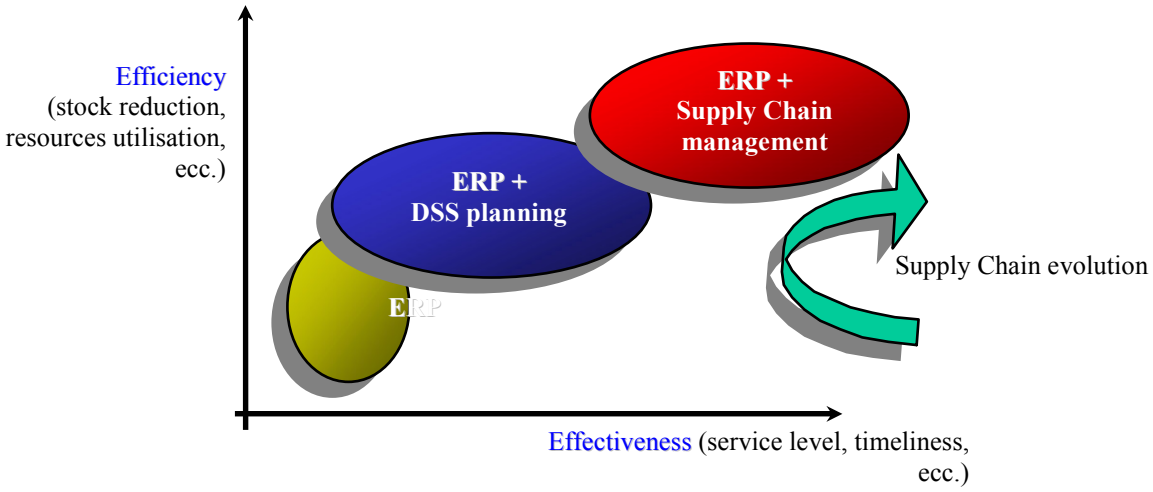

Figure 2: IT evolution at Supply Chain level

Nowadays, the integration between APS and ERP 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.

The integration problem is indeed extremely complicated by the intrinsic differences existing between APS-SCM and ERP systems (see some differences in Table 1).

	ERP	APS-SCM
Approach	Transactional system	Interactive/simulative system
Analysis	What is – What was	What is – what will be
Frequencies	Batch run	Real time analysis
Focus on	Data management and integration	Shop floor simulation, material availability check, etc.
Production capacity	Infinite (indirect management by means of lead times)	Finite and detailed; each kind of production resource
Programs	Rough plans	Operational
Model	Company's business model parameterisation	Logistic and productive resources detailed model
Paradigm	Hierarchical top – down	Distributed with integrated control; bottom-up approach available
Computation logic	Easy (e.g. MRP computation)	AI, heuristics, optimisation algorithms

Table 1: ERP vs. APS-SCM key distinguishing elements.

Integration problem has to be faced following three directions:

- *technological integration*, concerning interfaces development and the set up of communication mechanisms between APS-SCM and ERP systems; IT innovations allow to define this task as a "non critical" one;
- *organisational integration*, very delicate topic since APS-SCM systems allow to integrate or distribute / outsource the control and the decision levels, designing organisational assets that are unmanageable without the specific IT tool; nowadays this is probably the most critical task even because of the lack of stable referring templates, (if compared with the availability of several ERP models, this confirms the embryonic stage of APS-SCM market)
- *managerial integration*, encompassing the allocation of the various functions to the APS-SCM or ERP system.

As far as managerial integration is concerned, in Figure 3 it's summarised the methodology that, starting from the deployment of company's business requirements and the analysis of company's specific features (critical success factors, industrial sector characteristics, organisational culture), allows to design the critical processes and, on the basis of decisional content and of *what-if* analysis requirements, puts the border between APS-SCM (DSS application) and ERP (or legacy) solution.

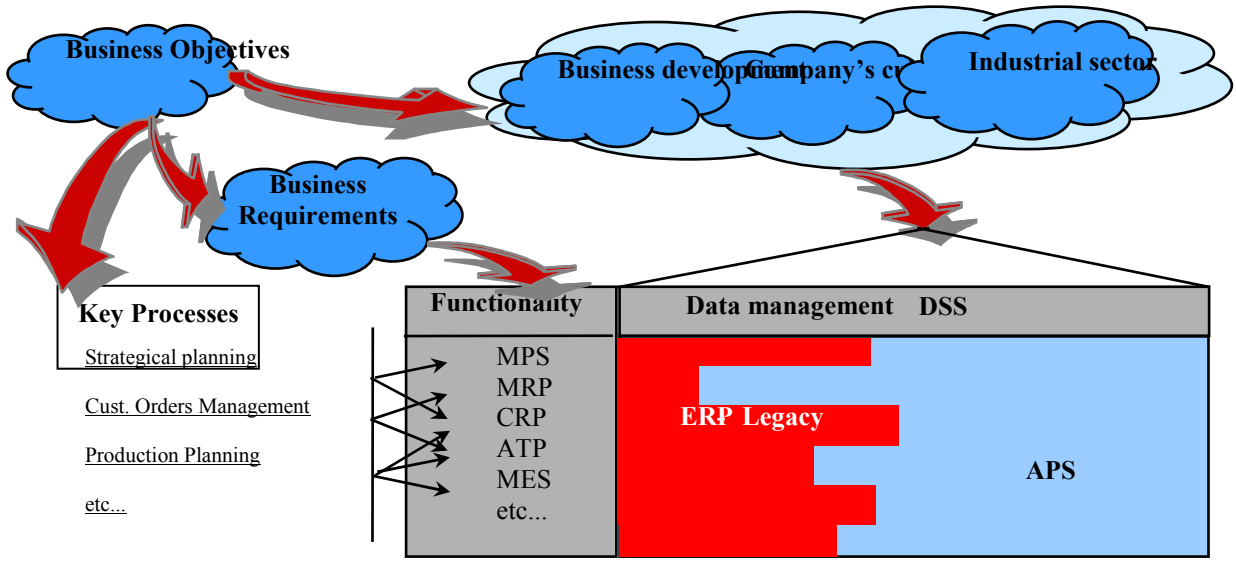

Figure 3: Integration design methodology

Once the theoretical managerial integration layout has been designed, it's necessary to face with the architectural solutions allowing integrating APS-SCM and ERP system. The architectural solutions are:

- "Off line" integration in which entire steps of the production planning and control cycle are in charge of the APS-SCM system (e.g.: customers order are inserted into ERP system, then they are collected and by means of a batch interface are downloaded to the APS-SCM system; APS-SCM, in an asynchronous ways, schedules production orders, loads work-centres… and finally feeds back the results to ERP system). This solution is "simple" from a technological point of view (the most critical task is designing the interfaces), but imposes several constraints, mainly concerning the synchronisation of the two systems;
- "Add-on" integration that is a pure real time integration, in which every APS-SCM sub-functionality (e.g. ATP calculation) can be launched (triggered) in ERP environment.

In Figure 4 the two architectures are summarised; it's evident how the second solution is much more complex than the first, but allows a greater flexibility level.

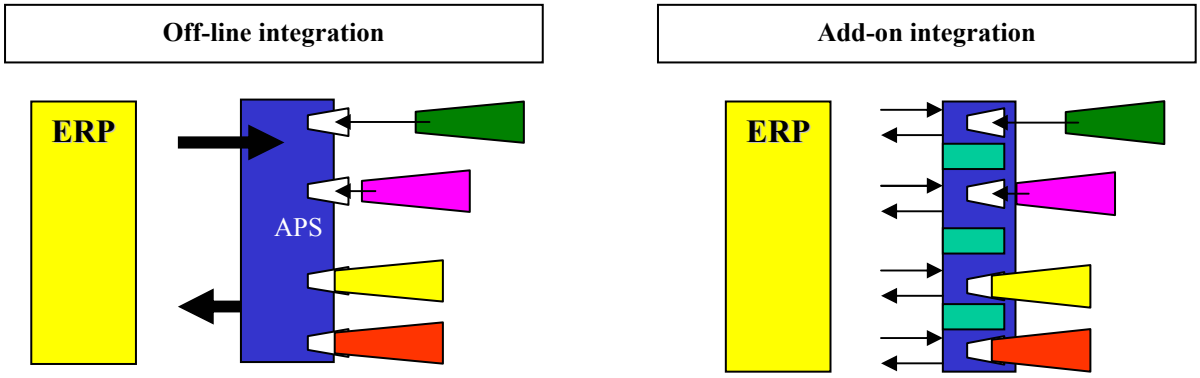

Figure 4: "Off-line" and "Add-on" integration architectures

CONCLUSIONS

In this paper the latest evolution of IT tools for Supply Chain Management has been depicted. Nowadays, APS-SCM are the most enhanced support to production planning decision making. On the other hand, ERP systems have a world-wide diffusion because they offer the possibility of managing company's data in an integrated and standardised way.

One of the most critical problem to be faced today at IT level is the integration of APS-SCM tools with ERP systems. The most frequent questions emerging while managing such integration are related to the position of data (bill of materials should be stored in APS or ERP systems?), to the location of procedures (should I use MRP legacy or enhanced APS's MRP?), to synchronisation of APS and ERP (is APS procedure triggered by ERP or should it run in asynchrony?), and so on. The answers to these questions have a great impact upon technological features (databases, system architecture) but even upon managerial aspects (frequency of planning or rescheduling, …).

An empirical methodology that focuses its attention on managerial integration has been summarised in the paper. The proposed methodology is based on the consideration that functionality integration design and architecture definition should be faced in sequence steps.

Notice in fact, that the first phase of the methodology (requirements analysis) does not depend in any way from the knowledge of the specific APS-SCM solution proposed by Vendors, neither upon the specific architectural configuration it will assume. The first effort while integrating APS-SCM systems with an ERP has to concentrate upon the real business requirements, later on the possible information support will be taken into consideration.

From direct experience in many APS-SCM projects of integration with ERP systems, the authors have learned the lesson that a successful guideline is "*first understand what you need and then find out how you can be satisfied*", that is to emphasise managerial integration aspects that shall be absolutely faced before investigating the technological architecture of ERP-APS/SCM integration.

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