State of the Art

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The Successful Implementation of Advanced Planning and Scheduling Systems

Companies undertake the implementation of advanced planning and scheduling systems (APS) with high expectations of achieving greater value from their enterprise resource planning (ERP) system. For the many who recognize that their profitability and growth are constrained by the difficulties of coordinating production, distribution and order fulfillment, a promising solution appears to be offered by automated planning and scheduling. Unhappily, even after a costly investment in software, systems engineering, and the interruptions to operations required by the implementation, those hopes are often unrealized. Why is it so difficult to implement advanced planning and scheduling systems? And is there a practical alternative?

Fundamental Shortcomings

When you dig into the details of a failed APS, you find the problems are many, but they are attributable fundamentally to 3 causes:

1. Lack of experience in modeling and optimization
2. Limitations of the underlying software, and
3. Faulty methodology used during the implementation.

In this paper we explain the nature and implications of these 3 areas of deficiency. Then we describe an alternative approach that does offer a practical solution.

1. Lack of experience in modeling and optimization

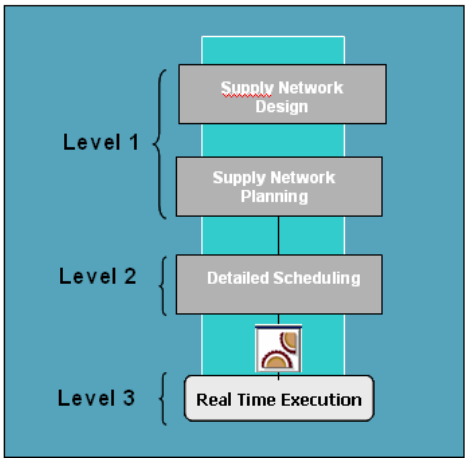
Modeling and optimization are not new mathematical concepts; they have been in the literature for awhile, but only recently have those concepts been applied extensively to solve complex business problems. Even today, optimization is a topic of intense academic research and new and powerful computational implementations of classical algorithms now enable us to solve huge problems in a

relatively brief amount of time. New algorithms have appeared that promise to solve complex problems in ways that lend themselves to practical applications.

But modeling – that is to say, the positing of variables and the relationships between them - is still an art. It depends on the modeler's sound judgment, experience and insightfulness. The same problem can be represented in different ways for different models, and the model behavior and usefulness of solutions depends on the model structure. There exists no pre-established set of rules to correctly formulate a model; it is a matter of deeply understanding the problem, constructing the model and then selecting appropriate algorithms to solve the model.

Correctly defining the problem is in itself a significant issue. It is not unusual to come across a blurred problem definition and this leads inevitably to an ineffectual model. As far as supply chains are concerned, correct definition of the problem occurs at three levels: Planning, Scheduling and Execution. Each of these levels requires a different approach and different definition of the problem to be solved.

- **Planning** is a holistic activity, with a discrete time horizon, and is the way to coordinate activities between different processes and process states. Planning generates concurrent, simultaneous and mutually consistent plans for process activities such as supply, production, inventory, distribution, transportation and service.
- **Scheduling**, in contrast, is a local activity, with a continuous timeframe that deploys sequences of activities to be implemented by operations.
- **Execution** is a punctual activity; it monitors deviations between the schedule and actual execution, then makes adjustments when necessary.



As noted above, decisions at these three levels are different in nature and entail different problems. Moreover, it is important to tackle these problems in the right order. Beginning with planning and proceeding through scheduling to execution has proven to be the logically correct way; whereas progressing upward from execution to planning has been shown to be impractical and inefficient.

2. Limitation of the software platform

In terms of software design, there is a fundamental mismatch between transaction-based ERP systems and the dynamic requirements of planning and scheduling. The ERP system, with a huge database at its core, is designed to record many transactions and propagate derivative values of those transactions throughout the database. The database is intended to be a comprehensive, accurate repository of all information pertaining to operations of the enterprise that can be shared and accessed by employees to carry out their responsibilities. Accordingly, core functions of the database include updating table values, locking cells while updates are underway, validating data by type, and rolling back values when a change needs to be undone. These capabilities of the database importantly enable the ERP system to maintain an accurate record of current and past information and to receive new information, ensuring its consistency and integration with existing data.

The ERP's front end handles tasks such as order entry, tracking of work in progress, and order fulfillment that send and request data to and from the database in the form of transactions.

Planning and scheduling, however, are different in kind from most other ERP activities. Most ERP activities, like order monitoring and inventory tracking, involve many people throughout the company viewing and entering small amounts of information at a time. Planning and scheduling, on the other hand, involve relatively few specialists interacting with fairly large amounts of aggregated and even extrapolated data. Moreover, the planning specialists repeatedly fabricate imagined, hypothetical scenarios; they project beyond the database's current and historic data to understand what could happen in the future. Their needs are computationally intensive and the computations depend heavily on dependencies between interrelated entities, for example, between a production line and the capacity of the equipment that it comprises.

The ERP system can serve as a useful source of current and historical data for the planning and scheduling system, but it is miscast as a platform for that system. Those features that enable the ERP system to manage large amounts of shared data are simply a burden to the APS: they delay and complicate the calculation of simulation and optimization. Slow response time dooms many an APS system. It is not unusual for companies to report that their simulation and optimization runs require 12 hours or more, even after imposing some simplifying assumptions to enhance performance. When the response is so slow, the planner cannot explore multiple solutions in order to arrive at the correct solution; even worse, reactive scheduling is out of the question because the recommended changes arrive too late to be put into effect.

3. Methodology

APS packages are marketed with an attractive list of features – finite capacity planning, yield management, available to promise, and so on – that are meant to satisfy the various needs of all companies. Evaluating those features is a daunting task. It is often difficult to understand what functionality is implied by a particular marketing term and more difficult still, to know whether it is truly necessary or even useful. There is always a lingering suspicion that the state-of-the-art feature that sounds so powerful in the sales pitch won't actually work in the context of your company. And, unfortunately, those suspicions often turn out to be justified.

A software package by its very nature is pre-defined and therefore, no matter how much the salesman may claim that it can be configured and customized to fit your company's needs, its capability, structure and style are largely determined. Consequently, adjustment and accommodation are required from the users themselves; the software doesn't accommodate their way of doing business but instead they must adapt to the software.

Moreover, the implementation methodology of those packages reflects the fact that the APS is pre-defined. Instead of starting with an understanding of how your company currently operates and then designing the ERP system to match and facilitate those policies and practices, the APS implementer conducts training and reengineering to reorganize your company's practices to align with the software. Sometimes that works, but often it doesn't, and either way the process is disruptive to the company and employees. Not infrequently in order to derive a solution planners find themselves

going back to their old, manual techniques (perhaps on the sly so management doesn't find out) because the scheduling package doesn't quite fit their reality.

In conclusion, no matter how powerful and sophisticated the capabilities of an APS system, if it doesn't match and facilitate the company's way of doing business then it will not prove advantageous. Moreover, adoption of the APS will probably be resisted by the end users.

One Company's Experience

"Promise only what you can deliver; then deliver more than you promise."

In the mid 1990s Mexico's largest glass company faced increasing competition and found themselves especially vulnerable to those competitors when the products their customers sought were unavailable or delivered late. Up to that time they had dominated the Mexican market for flat glass, providing more than 90% of the glass for automobile windshields, buildings and furniture. With the opening of the Mexican market to international vendors, however, customers could turn to alternative suppliers and therefore the company was forced to refocus its attention on improving and maintaining its level of service. Otherwise it would continue to lose market share.

When they turned their attention to scrutinizing service, certain problems became apparent. One problem was that particular products were sometimes out of stock when customers wanted to order and the availability dates that Sales could offer were uncertain or far into the future. Furthermore, when Sales did take an order and promised delivery for a certain date, they sometimes encountered delays and delivery was either late or partial. It seemed that the plants' production schedules were irregular: there were insufficient inventories of some products while others were piled in excess. The salesman might consult projected stock availability for future months then promise delivery of a product to a customer by a certain date, but the schedule was subject to change by the plant during operation so that product might get bumped for any number of reasons. Creating a production plan that maintained inventory of all products at a satisfactory level appeared to be an impossible task.

The scheduling problem for this glass company can be described briefly as follows. The company has 3 plants in Mexico with a total of 4 furnaces among them. The molten glass is poured from the melting furnace to a float bath where it cools to a ribbon and then, while it is still pliant, rolled to specified thicknesses and then cut into slabs. In the manufacturing process, the furnace is the critical piece of equipment because it holds the molten glass that feeds the floats. It also consumes important resources, in particular energy and time for startup. With that in mind, operators and schedulers are attentive to keeping the furnace running continuously once it has started up. The molten glass has a certain color and composition that are specific to the product and correspond to a certain recipe and ingredients. When the plant has finished making as much as they in tend to of one product, they shift immediately to the next. That shift in production from one product to another requires a transition from one recipe to another and there is a cost implied in that transition as well. Operators and planners try to avoid drastic recipe shifts (for example, a dark color to a lighter one) that would aggravate waste and cost.

The plants' operation is planned in terms of campaigns that correspond to a single color and sub-campaigns corresponding to a certain thickness. Looking ahead for the year, planners need to schedule campaigns so that they will produce enough inventories to meet expected demand for each product up to the time that another campaign begins for that product; otherwise they will encounter stock outs. One of the critical variables for

planning, then, is a reasonably accurate forecast of demand.

In their examination of service, the company found that stock outages were both a consequence and a recurring cause of alterations in the production schedule. Other disturbances were due to priority having been given to an important customer or order. Day-to-day adjustments to the schedule could have repercussions that impacted tasks planned for weeks in the future and those repercussions were not easy to foresee using the scheduling tools they had at hand -- spreadsheets and sticky notes stuck to a wallboard.

The scope of the problem had been discovered but the solution was still unclear because causes and effects seemed to be intertwined. Salespeople blamed Planning because projections of product availability were undependable. Planners responded that if Sales would provide more precise information about expected demand, then they could design production plans that would meet inventory targets. Even so, they added, the plants don't always follow our plans, instead they make changes that diverge from the plan and delay availability of some products. The plant operators, in turn, replied that it wasn't their fault that production schedules were disrupted because they were only following instructions from Management to accommodate unplanned, special orders, often at the urging of Sales. The finger-pointing led only in circles and not toward a solution.

The company hired a business consulting firm to study the situation. They concluded that poor communications between operating units lay at the heart of the problem. Their recommendation was to reengineer the channels of communication and assignment of responsibility so that more reliable, timely information would be generally available; planning would become more accurate and inventory problems would disappear or at least, it could be hoped, diminish. Following the recommendations and guidance of those business consultants, the company redefined peoples' roles so that they had explicit responsibility for information and tasks related to production planning and execution. Furthermore, they defined policies and mechanisms for gathering and disseminating detailed information regarding expected sales, products and assignment of inventory well into the future, more than 20 months. It was a fairly disruptive, time-consuming program and, after it had been in effect for a couple of years, the results were disappointing.

As part of their solution to gather and organize production information, the business consulting firm had recommended an ERP system. That system had proven useful for collecting and structuring information so that it was available to decision makers. Aside from reports, however, it did not provide information that helped in deciding, for example, what campaigns should be run at which plants and for how long, or whether one product should be made before another. The ERP system was not able to optimize production nor did it have the capacity to help the planner to explore "what-if" scenarios of possible production plans for the future. Those decisions still depended on individuals and, even though their responsibilities were now more clearly defined and they had more information at hand, they were still unable to plan and execute production schedules that worked efficiently.

The vendor of the ERP software offered an add-on package to solve the glass company's planning difficulties. This Advanced Planning and Scheduling module took advantage of information from the ERP system to create, or so the vendor promised, optimized production schedules that would effectively cover demand. Management bought the APS package together with engineering services for its configuration and installation. Configuration turned out to be a lengthy process and in several respects the APS was inflexible therefore requiring that scheduling tasks be conceptualized differently than the company's planners were accustomed to doing. Because the package was predicated on pre-established concepts and methods, training courses were an important component of the implementation. All of those who had some responsibility for planning and scheduling in the company received training in how to use the new APS system and for many it required that they learn and adopt a different way of carrying out their assigned tasks.

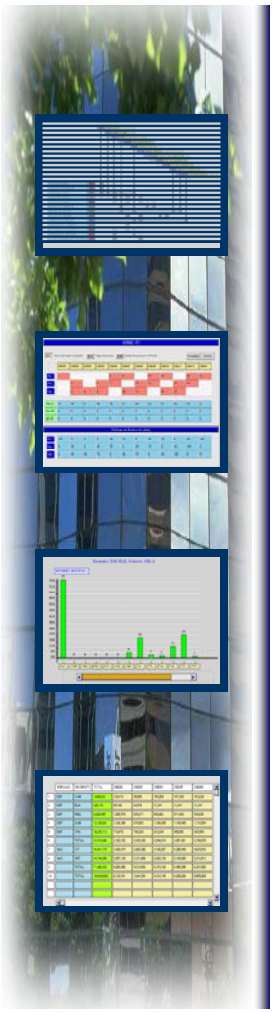
Unhappily, the new APS system was no more effective at improving product delivery and customer service than the reengineering scheme had been. In fact, the managers who were responsible for production

scheduling reverted to their old, manual systems in order to generate schedules because the results of automated APS system were manifestly unrealistic. For example, a solution proposed by the APS system might be almost correct but wrong in a particular detail that would render the whole solution unusable. Part of the problem was that the system was automated to such a degree that the user had ceded control; he couldn't revise the solution to a reasonable plan and then test it to see the ramifications. The solution was "take-it-or-leave-it" and so many chose to return to their old techniques which produced results that were at least feasible if not optimal.

Eventually management recognized that the APS system was ineffective and even rejected by the very planners for whom it was intended. The money and effort spent on the APS system had been wasted. They turned instead to augmenting a solution that had previously been used in more limited scope within the glass company, a solution built by Aleph5 using the Ernest software package.

Aleph5 began by meeting with operators, managers and directors to understand their goals and how they carried out the tasks that were related to planning and scheduling. Aleph5's approach, unlike the APS vendor's, intended to adapt to and support the users' ways of working and therefore building a model of operations that was familiar to users was an important first step. The building blocks of Ernest, while largely open to specification, did provide a basic structure that had proven to be effective for these types of applications; specifically, it organized the modeling into three levels of activities: planning, scheduling and execution. The methodology dictated that a yearly plan be developed that encompassed all 3 plants so that production could be balanced optimally across plants. The metrics considered economics as well as service and they included consideration of demand as well as cost of transportation in the distribution channels. An executive committee participated in the design of the model and engaged in "war room" exercises to test the model under different scenarios.

The yearly plan set the targets and boundaries for the production schedules which were generated for each plant on a shorter, weekly time horizon. The campaigns and sub-campaigns composed those production schedules. And third, the execution model ran more frequently, sometimes several times a day, to keep production in line with targets and adapt to unforeseen changes in the production process.



Aleph5's approach proved successful on several counts. First, it did enable planners to improve timely delivery to customers while at the same time reducing excess inventory. Second, it was embraced by operators and planners who realized that it made it easier for them to fulfill their responsibilities. Third, above and beyond their expectations, it led management to consider alternative business practices. For example, taking a holistic perspective on planning enabled them to realize that it could be more profitable in some instances for the company to OEM another glass company's products rather than make them themselves; their own resources could be allocated more profitably to another product of their own. The planning model enabled them to consider such a hypothetical alternative and to measure its expected advantage

Lessons Learned

Learning from your mistakes is an important quality of successful companies. Clearly the Mexican glass company made several false starts before they hit on a solution that worked. Surprisingly, perhaps, the best solution turned out to be the one that was nearest to hand. Their attempts, first to reengineer communications and decision-making and then to shoehorn the planning package from their ERP system, led only to disruption and disgruntlement. When instead of trying to change workers' behavior they adopted an approach that supported and promoted their own best practices, then the process met less resistance and, eventually, positive acceptance.

A second lesson learned is to choose the right tools for the job when it comes to software. Planning and scheduling activities are accomplished most successfully through the interaction of people and computers, that is to say, decision support. There is little benefit to a system that produces what purports to be an optimal solution if it is inexplicable to the planner, worse yet if the solution contains some apparent flaws. The most effective APS systems are those that enable planners to carry out their responsibilities most efficiently and those systems should be model-based, dynamic, and capable of simulation.

Finally, the glass company benefited from Aleph5's expertise in the area of modeling. While it might be said that operators and managers within the company could name most of their day-to-day scheduling and planning problems, they couldn't see the trees through the forest. That is, they couldn't perceive what was cause and what was effect and so they didn't know where to begin in solving their problems. It required Aleph5's experience to decompose the problem and then structure the solution with a series of objectives to be solved and different levels of operation and differing frequency.

In short, Aleph5's experience in solving APS problems together with decision support software and a methodology that leveraged the company's own best practices led to a productive solution. All this in less time and with less disruption than the earlier, failed attempts.

Conclusion

Failed initiatives to implement Advanced Planning and Scheduling applications are often due to a combination of 3 factors: faulty representation of the problem, erroneous choice of software, and poor design. Conversely, successful APS implementations correctly align the model's functional elements at each level with the objective to be achieved, differentiate between the ERP database as a data store and the reasoning engine for decision support, and involve users with varied company responsibilities in designing the system's behavior to their best practices.

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