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SIMULATION AS A FIRST STEP IN PRODUCTION PLANNING

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ABSTRACT

This paper presents a new role for simulation and ARENA. It is used to help companies in planning the production by executing the MPS - Master Production Schedule. This approach could be used as the first step in a planning system based on MRP/ERP, transferring the result to this system. This system is based on simulation, and it uses Arena/SIMAN V to calculate the schedule. It also allows any client-server database to be used to store data; e.g., Oracle, Sybase, Microsoft SQL Server 6.5, etc. This system was designed to support ERP/MRP in this planning as well as how it could indirectly help some FCS like Tempo from Systems Modeling Corp. deal with material requirements. The system was designed for a specific client with overseas operation and had to be integrated with SAP R/3. Therefore, the system had to be configured easily in other sites and had to support any other language, as well as new integration requirements.

KEY WORDS: MPS, ERP, FCS, Simulation, and Constraints

INTRODUCTION

Today the Industrial Systems like MRP/ERP, FCS, SFDC, CAPP have become more and more common on the shop floor. Nevertheless, the complexity of the entire system has increased, too, and new powerful solutions have arisen in this environment. Indeed, systems like SAP R/3 allowed a PC network to replace mainframes and made it easier for developers to built new, advanced systems to be applied on shop floor. In this scenario, new challenges and opportunities arose. Many FCS packages are examples of smaller and cheaper packages based on PC computers that took advantage of this situation. However, the MPS packages are still scarce. In this paper, the role of this planning system is discussed and a new package that runs on the ARENA simulation system is presented. This system could be used to plan orders to be scheduled by FCS.

1 INDUSTRIAL SYSTEMS BASED ON MRP/ERP

Industrial systems based on MRP/ERP have a complex relationship network among different modules. Some modules are responsible for material supply, order dispatch, shop floor data collection, and so on. However, the design of this system depends on how the company really works. For example, the companies that work with make-to-order are quite different from companies that work in an engineering-to-order or make-to-stock system.

When you consider manufacturing systems that yield repetitive goods and work in a make-to-order environment, the Sales Department (or sales order planning) is usually the first step in chain. Once an order is opened by Sales Department the Production Department is called to respond to the client about a due date. However, it is a complex task. The person responsible for scheduling has to understand the impact of this order, must be aware of inventory,

shipment dates, etc. This first approach should be as accurate as possible. Capacity, dates, and constraints must be considered here. Nevertheless, it is not important to know where the order will be produced (in which flowline) or what is the time that it will be scheduled. It is necessary to know if the plant has capacity to do this and what is the day that this order could be delivered. Therefore, after this calculus, the date is sent to the client for approval. Some disruptions in the shop floor have to be treated by FCS because they are usually problems that arise suddenly, and they are often impossible to predict.

2 MASTER PRODUCTION SCHEDULE

Master Production Schedule could be defined as "the result of the desegregation of the production plan. It lists the models to be produced, and in what quantities, in the next period" (Bedworth and Bayley 1987). It is important to point out that aggregate planning does not deal with specific items or products. It treats some very important issues (e.g., work-force size and production quantities for a plant) as a whole. Thus, to be useful, this plan must be detailed into production quantities for each item. This "desegregation" becomes the master production schedule for finished products. It is also the input for any MRP module.

2.1 A Simple Example About MPS Using a Simple Algorithm

The Master Production Schedule (MPS) sets the quantity of each end item to be completed in each week of a short-range planning horizon. The MPS is in fact the mother of all schedules, and it is a plan for future production of end items, set by market forecasts, customer orders, inventory levels, and other information necessary to make correct schedules.

The MPS sets its production schedules based on Forecast, Orders and Lotsize, and it provides information on Available-To-Promise and Projected Available Balance. The ATP is a percentage of what is promised to the customer and what is realized from those promises. In fact, it is the amount of "promises not kept" divided by "promises kept" (Baaijens 1996).

There are procedures for developing an MPS. But before one develops an MPS one has to know what an MPS is like. Master Production Schedules can be seen as divided into four sections, all separated by a point in time: the time fence. These time fences divide the MPS into four parts as shown below. Of course the different sections can differ in time-length.

Frozen **Firm** **Full** **Open**

Let's assume a firm is producing two products: Product A and Product B, on a make-to-stock basis. Demand for those two products is given below:

Weekly Demand (Product A)

	Weekly demand					
Sources of demand	**1**	**2**	**3**	**4**	**5**	**6**
Internal orders	**—**	**—**	**30**	**40**	**20**	**10**
Warehouse orders	**—**	**—**	**20**	**—**	**10**	**—**
R&D Orders	**10**	**—**	**10**	**10**	**—**	**—**
Customer demand	**20**	**20**	**20**	**20**	**20**	**20**
Total demand	**30**	**20**	**80**	**70**	**50**	**30**

Weekly Demand (Product B)

	Weekly demand					
Sources of demand	**1**	**2**	**3**	**4**	**5**	**6**
Internal orders	**—**	**20**	**10**	**—**	**10**	**—**
Warehouse orders	**—**	**—**	**20**	**10**	**—**	**—**
R&D Orders	**—**	**—**	**—**	**10**	**10**	**10**
Customer demand	**30**	**30**	**30**	**20**	**20**	**20**
Total demand	**30**	**50**	**60**	**40**	**40**	**30**

Both A and B have safety stocks: A has a safety stock of 30 and B has a safety stock of 40. The fixed lot size of A is 50, and the fixed lot size of B is 50. Starting inventory of A and B are 60 for both.

Now everything needed to develop an MPS is available. The logical formula used to calculate the MPS is as follows:

- *IF Inventory - demand > safety stock THEN produce nothing.*
- *IF Inventory - demand < safety stock THEN produce fixed lot size*
- *IF fixed lot size is produced THEN ending inventory must be > Safety stock.*
- *IF ending inventory< Safety stock THEN produce 2 times (or more) fixed lot size.*

After using these formulas, the MPS for both product A and B will be like below:

End Item	**Weeks**						
		1	**2**	**3**	**4**	**5**	**6**
Item A	Total demand	**30**	**20**	**80**	**70**	**50**	**30**
	Beginning inventory	**60**	**30**	**60**	**30**	**60**	**60**
	Required production	**—**	**50**	**50**	**100**	**50**	**—**
	Ending inventory	**30**	**60**	**30**	**60**	**60**	**30**
Item B	Total demand	**30**	**50**	**60**	**40**	**40**	**30**
	Beginning inventory	**60**	**80**	**80**	**70**	**80**	**40**
	Required production	**50**	**50**	**50**	**50**	**—**	**50**
	Ending inventory	**80**	**80**	**70**	**80**	**40**	**60**

3 SIMULATION

Many Advanced Industrial Systems that are applied in manufacturing decision-making are based on simulation. Finite Capacity Scheduling, Supply Chain systems and Master Production Scheduling are usually based on it. It is important to point out that the main problem is related to the fact that it is necessary to build a model that could represent how a system works. This model is used with some mathematical tools, Artificial Intelligence procedures, or heuristics to calculate the response of the system under certain conditions. These results are used to indicate the best alternative available for this study. It does not mean that it is the best alternative in the actual system. However, it can drive the decision maker to a good option. The simulation is certainly a good tool to predict the behavior of the system with a great adherence. It is usually easier than trying to describe a manufacturing system by a linear system.

4 CONSTRAINTS

The Theory of Constraints says that production resources are not independent links, but instead are a chain of dependent links, working toward the shared goal of making money. Just as the weakest link determines the strength of a chain, a handful of critical resources dictate the performance of a plant. By first identifying and scheduling those

constraints, you could maximize the total performance of a plant. A traditional approach to maximize the production on a bottleneck (or constraint) is trying to minimize the number of setups or trying to minimize the time spent doing it. Therefore, the algorithm must be compliant with this issue. However, it is necessary to ponder some other very important issues; e.g., due dates, client priorities, and mainly the capacity to supply components to the plants. Therefore, it is really a multi-criteria decision process.

5 ARENA FEATURES THAT INDICATE ARENA IS THE BEST SIMULATION TOOL AVAILABLE FOR THIS SYSTEM

Arena is a visual simulation tool that is based on the SIMAN V simulation language. The power of this language and the flexibility of building objects make Arena a very powerful tool. It can involve the most problems and features necessary to model the behavior of any company. Thus any change could be easily added to the system. Since Arena was powered with VBA, it also could be considered a very attractive development environment. This feature permits that Arena can access any type of database, transferring data from and to them. Hence, the user could model a manufacturing system, use the data that are stored in a corporate system and test them with these parameters. The result could be stored in another database and analyzed by specific tools.

6 THE SYSTEM DEVELOPED

The system developed by SEED is based on simulation, client-server technology, running on a Windows 32-bit platform, Windows 95/NT 4.0;

Some features of the system:

- The model is built using Arena 3.01;
- Any database could be used, however, Oracle Database version 7.3 is preferred;
- Reports could be generated by user using Crystal Reports and added to the system;
- Microsoft Universal Data Access compliant;
- COM+ compliant. DCOM-compliant version is planned to be released soon;
- ActiveX servers are responsible for business services;
- The system is opened for customizations.

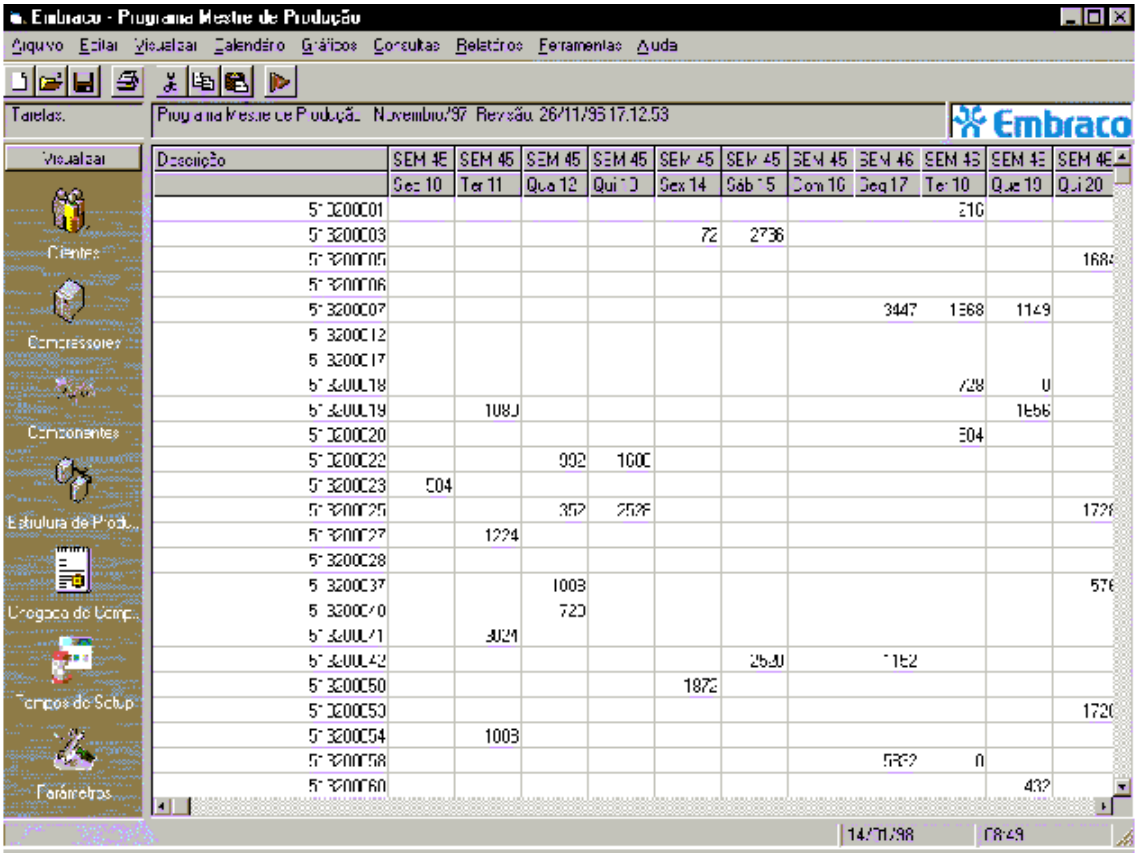

Figure 1: The main form. The spreadsheet in this form shows the code of products, the day scheduled and the quantity necessary for each day.

Figure 2: The system is based on Wizards. The above example is responsible for setting constraints for a specific day.

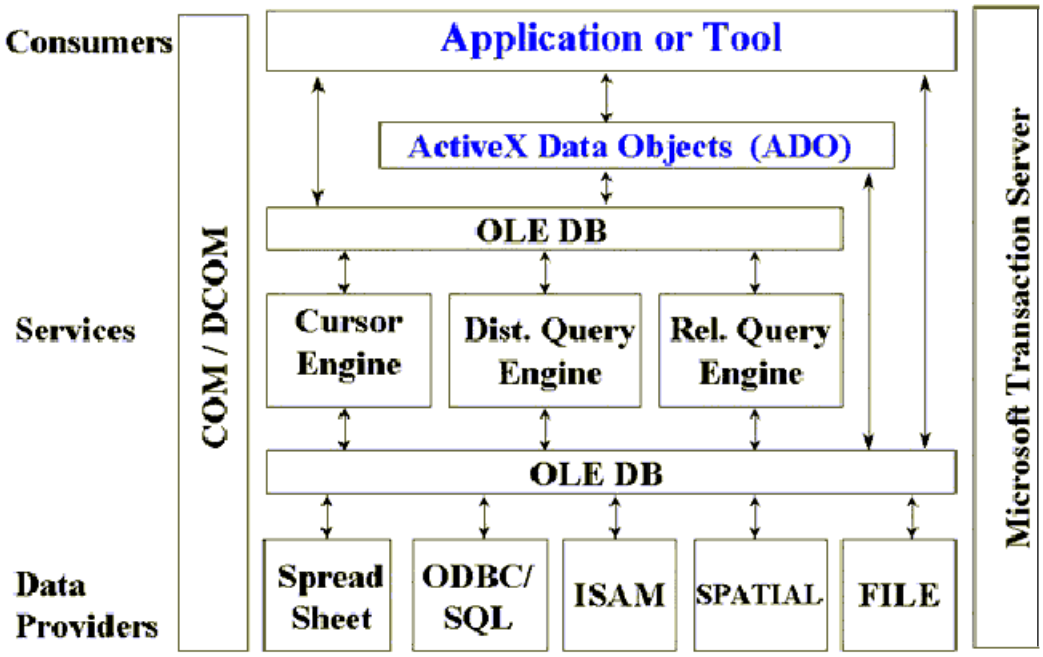

Figure 3: Universal Data Access (Source Microsoft Corporation.)

7 MPS AND ERP

MRP system is driven by the master production schedule. The MPS begins as a trial schedule. If these schedules are feasible, the schedule becomes input for the MRP system. MRP sees this schedule as given: the system cannot check if a schedule is correct or incorrect, for example, if a schedule goes beyond production capacity or not. The MPS can be updated or modified any time a production manager wants. As a result of these changes, the MRP input changes, as does the production output.

Some ERP are developed to work with third-party systems. SAP R/3 is an example that it is possible. It has a specific interface to allow that data could be generated by another system and transferred into it. Therefore, MPS is responsible to inform the corporate system about quantities, and the items that must be produced. It schedules orders in a rough sense, verifies inventory and predicts delivery dates. It is usually the first step in a planning system based on ERP/MRP.

8 MPS AND FCS

After the orders were generated by MRP/ERP, the FCS could use it to manage the tasks on the shop floor. FCS receives these orders and schedules them into each flowline, machine, workcenter, etc. It deals with short-time issues, e.g., it is responsible for managing the system when a disruption like an unexpected breakdown occurs. Using this system, FCS could be capable of scheduling orders that have feasible due dates. Therefore, this system will isolate and reduce the problem related to material supply as well as it could favor FCS with more accurate due dates and start times.

CONCLUSION

Thanks to some new features of Arena, like VBA, it is easy to model the system and connect it into any other database. Arena has also shown that it could be used as a development tool when simulation is necessary. There is no doubt that this approach using simulation could be considered as an up-to-date method to deal with this such problems. It demonstrates that it is a powerful solution, when dealing with complex systems. The ability to support material constraints could bring new strength to TEMPO in MRP/ERP implementation.

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