ORDER PLANNING DECISION SUPPORT SYSTEM FOR CUSTOMER DRIVEN MANUFACTURING: OVERVIEW OF MAIN SYSTEM REQUIREMENTS

Keywords: Production Planning, Scheduling, Decision Support System, Customer Driven Manufacturing

Abstract: An important goal in schedule production orders through a manufacturing facility is to assure that the work is completed as close as possible to its due date. Work that is late creates downstream delays, while early completion can be detrimental if storage space is limited. Production planning and control manufacturing is becoming more difficult as family products increase and quantity decreases. This paper presents an ongoing information system development that aims the production planning of special test tables equipment for automobile components manufacturers. The simulated based information system will be used to support planning and schedule activities; to compare and analyze the impact of planning rescheduling; to forecast the production completion date; to detect bottlenecks and to evaluate machines performance.

1 INTRODUCTION

Currently manufacturing companies are faced with markets which demand a great variety of products, with ever shorter lead times and smaller but more frequent order quantities, accompanied by more frequent changes. These companies must therefore make their production system more flexible and agile, reduce continuously the production and storage costs and react rapidly to new customer requirements and fluctuations in demand. For these reasons, customer-driven manufacturing is the key concept for the factory of future.

Customer-driven manufacturing requires greater customer satisfaction at lower cost. In addition, tailoring the product to the customer's needs is becoming increasingly important in quality improvement. In this environment, the availability of the right kind and quantity of resources able to engineer, manufacture and assemble a product in line with the customer's needs is very important. Therefore, the engineering and production processes constitute the manufacturing system that has to be managed (Wortmann *et al*., 1997).

The work presented in this paper was guided by the design and implementation of a order planning decision support system, addressing the requirements of a make-to-order environment, in order to produce realistic satisfactory delivery dates. This work has being developed under a research project in collaboration with a manufacturer of special test equipments for the automobile industry, and the ultimate objective of the work, as expressed by management, is to optimise the overall performance of the plant.

The frequent needs for anticipate deliveries or to satisfy customer's orders, that are crucial in company strategy, give rise to constant changes in current production orders, as well as this situation results in loss manufacturing capacity. In order to overcome these limitations, the system under development aims to simulate the company's engineering and manufacturing process. This will allow evaluating the effectiveness of the engineering and manufacturing process in terms of resources performance and in terms of quality of planning schedule generated. Also, the company will be able to analyze the impact of rescheduling the manufacturing planning and to predict the production orders finish date and even detects possible bottlenecks.

In order to model the information system under development, an object-oriented approach was followed, namely the UML - Unified Modelling Language (Booch *et al*., 1999).

This paper is structured as follows. The following section describes the company, presents their manufacturing process, and concludes with some issues concerning production planning and control. An overview of the main requirements for the decision support system under development is presented in section three. Finally, we will summarise our results and make a brief reference to some topics for future work.

2 THE CASE STUDY

2.1 Company Description

The company to which reference is made throughout this paper produces special test equipment tables for automobile test components manufacturers, namely cable testing tables. For each variant of automobile cable, the company, at most, produces three testing tables and they are always product specific. This means that the same testing table cannot be used for different automobile cable models.

The most important organisational aspect of the company is their manufacturing production model to be *Make-to-Order* oriented. The company plans the production taking into account firm customer's orders and available capacity. Even though they have a product portfolio, every potential customer order, due the particular technical specification, is nearly always a new product, and their manufacturing cycle time is usually very tight, normally between two or three weeks.

2.2 Manufacturing Process

The company considered here is a make-to-order firm, with a discrete production model, which manufactures and delivers complex products. The total operations for realizing an order consists of partly overlapping phases: design and engineering, procurement, component production, pre-assembly of subsystems, final assembly and testing. Within the manufacturing plant, the resources are organised as a functional layout, exploring at cell level, group technology. This layout organisation was prepared for 'one-of-a-kind' production and can be conceptualized and managed as job-shop manufacturing environment. In these areas are manufactured all components and assembled the final product, according order specification. In Figure 1 is represented one of the core company's processes: the production business process with its sub-process.

2.3 Production planning and control issues

Production planning is an important task within a manufacturing system. We define the planning system as that part of the manufacturing system that is responsible for regulating, coordinating, and monitoring the flow of work through the production system. The way the planning system accomplishes its function strongly influences the performance of the production system. Presently the company performs the production planning based on the delivery date of each order. When arrive a customer order, it goes to an orders queue. The orders with short delivery time are the first to be manufactured, what means that the orders are orderly by priorities

Top priorities are given to express deliveries and normal priorities are given to orders with large delivery margin, being their priority raised as due date became closer. In the beginning of every week the production department analyzes the delivery date for each order and with that, the current production status, the tables lifetime and the better management practice the week planning schedule is done.

This brings two problems for the company, the major is that the capacity needs in different phases of production changes abruptly as the needs for anticipate deliveries or to satisfy orders that are crucial in company strategy. The effect is that modules progress through production quite randomly and the lead times became longer what results in a high level of WIP (*Work-in-Progress*).

The second problem is a consequence of the first, i.e. if the manufacturing isn't executed as initial planned, the manufacture planning becames unreliable, turning almost impossible assess the impact of new orders acceptance.

Ideally, the planning and control method should level the need for capacity in a way that allows for prediction completion for each order and simultaneously results in adequate capacity utilization.

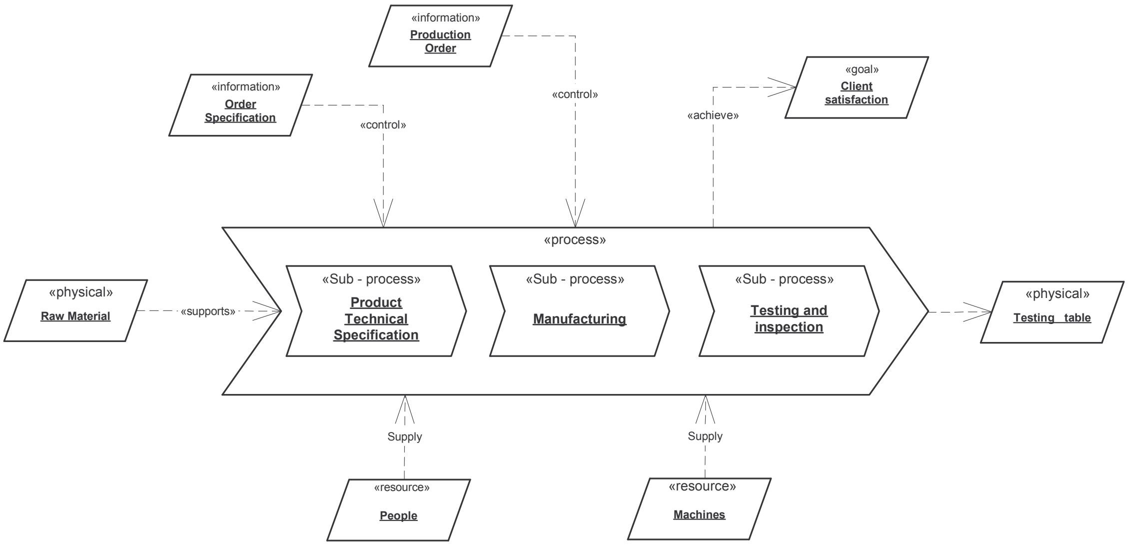

Figure 1: Business Process "Production"

3 OVERVIEW OF SYSTEM REQUIREMENTS

3.1 Context

In recent years, there has been an enormous research interest in topics such as manufacturing modelling and simulation, techniques of due date prediction, capacity planning methods and decision support systems for order planning. Such interest comes naturally from the need to respond to extremely competitive and dynamic environments shaped by an increasing globalisation, fast technological advances and customer-driven manufacturing. In fact, information systems for customer-order production raises several specific requirements, which distinguish these systems clearly from systems designed for make-to-stock production.

Related to our problem there are several research references. New *et al*. (1991) present a visual interactive implementation of simulation for capacity planning for an FMS cell. Due to computational time, however, discrete event simulation tends not to be suitable for capacity analysis at the factory level. The detail involved makes the output 'nervous' to small changes. However, Srivatson and Kempf (1995) present an abstract simulator which uses WIP allocation rules to simulate the movement of lots through the system with large time buckets. Roman and del Valle (1996) present a method of assigning due dates by means of simulation once the job arrives at the shop, however the success of their method is reliant on the use of a certain dispatching rule.

The company here considered, had already try to implement commercial software at the manufacturing process level. Even thought the results were not dissatisfied, it takes to much time to setup the information related to each new order. In fact, the company tried two different kinds of software solutions. The first one was lot production oriented (MRP planning approach), but it reveals to much weaknesses, namely concerning some assumptions such as: lead times are assumed to be known and constant and fixed product routings. The second information system considered, was oriented to engineer to order production and the major weaknesses of this solution was the higher needs concerning project details (several types of data), it was specific or oriented for large and complex engineer projects.

In order to overcome these drawbacks, and taking into account the specificities of company's production system, the decision support system to be implemented aim to follow an approach based on simulation. The main goal is to develop a hybrid application that simulates the plant production system, loaded with the production plans under evaluation, in order to determine machine and cells performance, detect bottlenecks, forecast production completion date, compare and analyze the impact of planning rescheduling.

3.2 Main System Requirements

The system to develop should deliver the required functionality and performance to the user and should be maintainable, dependable and usable. In customer-driven manufacturing environment, it is crucial to provide fast, reliable and on-time responses when dealing with new customer inquiries and order commitments. These are the most important high-level and general requirements to be fulfilled by the system to be implemented.

System requirements are usually divided in into two classes – functional requirements and non-functional requirements. The first describe what the system should do and are perceptible to the user, while the second describes constraints on how the functional requirements are implemented, and are not necessarily perceptible by the user (Sommerville and Sawyer, 1997).

3.3 Functional Requirements

Capacity modelling. To allow capacity planning to be performed, the capacity of the different production cells in the shop floor needs to be appropriately translated into capacity models. This requires some form of interface to translate the ‘real world’ into a computer model. Each capacity model should provide a measure of the corresponding production unit capacity, support the creation of capacity plans and evaluate the implications of a given customer order (Azevedo and Sousa, 2000).

Support for order promising. The efficiency of the company is on its ability to make immediate order acceptance with absolute commitment to due date, quantity and quality (Azevedo and Moreira, 2003). Thus, when an order arrives to the enterprise, is necessary check its feasibility taking into account the existing capacities and the current manufacturing planning. The system must be able to answer the following questions:

- What the impact on the current manufacturing planning?
- On what date will be the customer request complete?
- What additional resources would be needed in order to satisfy the customer request?

Parts lifetime. This feature is considered a very important method for measuring the performance of manufacturing systems, as it is used to measure the time spent by a part in the system from the arrival time to the time that all its corresponding process are finished. We aim that the system will be able to produce estimate lead times for each component object of each production order.

Orders Detail. In order to execute the production schedule, it’s necessary specify first for each order, the list of components, the operation sequence for each component and it lead time.

Monitoring the production status. One efficient strategy to reduce production costs is by better control of the manufacturing process (Choi *et al*., 2002). By monitoring the production status is possible analyze on real-time the machines performance, detect bottlenecks, analyze the impact of this on the manufacturing process if disruptive events occur in one or more machines, and know all the orders status.

Global and cell optimization. In order to optimize the manufacture flow across the shop floor, and thus reducing the high level of *WIP*, the application must perform capacity optimization at cell and shop floor level.

3.4 Non-Functional requirements

Performance. The system response time depends on how detailed or sophisticated the capacity models and algorithms are. If the capacity models details are rough and the algorithms are simple, the system will be faster but no so accurate when using sophisticated algorithms and high detailed capacity models. In order to provide a faster response the system shall require a reasonably small amount of memory so that enough for being permanently resident.

Flexibility. The system must be flexible in order to allow the user to insert, remove, edit or move elements, such as production orders or operations sequences.

Legacy Integration. In order to reach feasibly responses on capacity planning the system must know the current production status. This is done by integration with current company information system.

Dynamic and accurate capacity models. Capacity models aren’t feasible if they don’t consider unexpected conditions. The capacity model must be able to adapt to the existent conditions by the time the planning is done, i.e. must consider the behaviour overtime of various factors, such as:

- Delays in production;
- Material absence;
- Variable output;
- Resources failures;
- Dependence of lead time on loading resources at operations start on production mix.

Usability. A friendly interface, flexible, with strong graphical capabilities and succinct and clear messages can raise the system efficiency.

3.5 Use Case diagram

One of the first steps considered in the modelling was to describe the system as a number of *use cases* that are performed by a set of actors.

A Use Case diagram presents a set of use cases, actors and their relations. Their common applications are usually divided into two - system context modelling and system requirements modelling. The former gives emphasize to the identification of the boundary system, their actors and the meaning of their functions, while the second consist on the identification of what the system should do, no matter how. Figure 2 and 3 illustrate some of the Use Case diagrams considered for the system.

3.6 Data requirements

The structure of the data to be considered is organized according to its nature and the context of its use. We identify the following data requirements in order to model the problem.

Demand information:

- Firm orders and sales forecast;
- Order control policies and dispatch policies;
- Demand pattern.

Manufacturing process and time information:

- Manufacturing process data (resources used, process time, queue time, setup time, alternate routes);
- Calendar data (shift information, holiday information, preventive maintenance information);
- Machine data (name, type, mean time to failure, mean time to repair, alternate resources data, preventive maintenance time);
- Bill of material structure;
- Monitoring data (state of operations available)
- Forecast data (scrap rate, stock levels, supplier lead-time and capacity, etc).

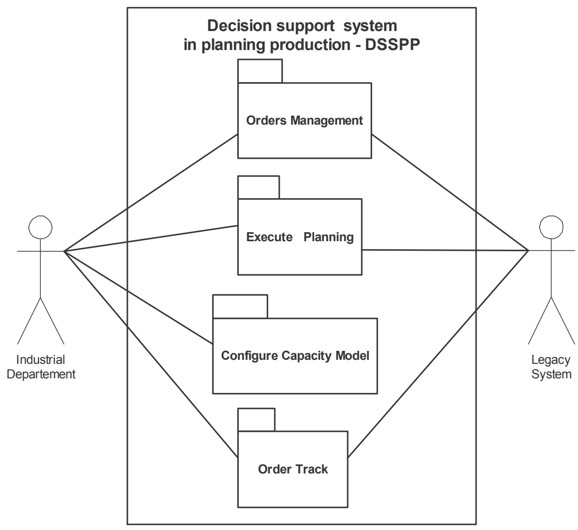

Figure 2: Use Case diagram for the proposal system.

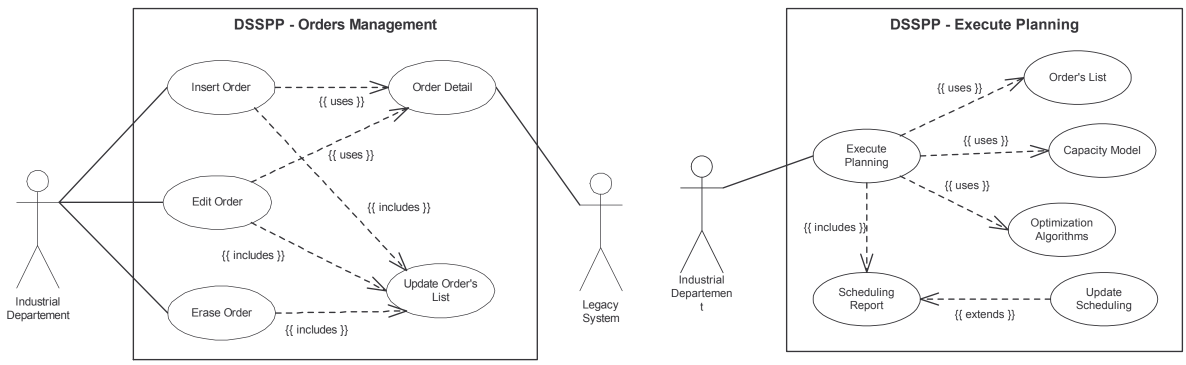

Figure 3: Use Case diagram for Orders Management package and for Execute Planning package.

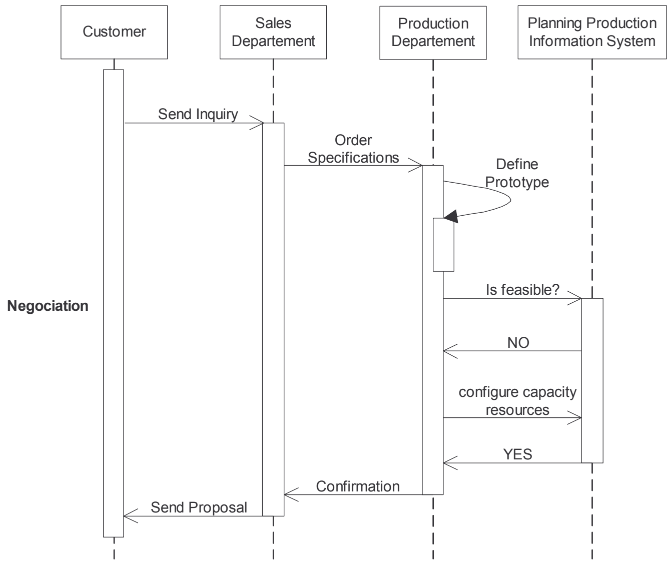

Figure 4: Sequence diagram representing Customer Inquiry

4 CONCLUSIONS AND FURTHER WORK

The work presented in this paper has been guided by the design and implementation of a decision support order planning system, addressing the requirements of a make-to-order environment. In fact, the goal is, the implementation of an information system, based in a real-time simulation model, able to produce realistic satisfactory delivery dates taking into account the available manufacturing capacity and the specificities of the company's manufacturing system.

Among the goals considered, we expected that the application would help to levelling the workload at each production cell, avoiding at the same time the high level of WIP at shop floor and provide the company with a toll that allow to assess the impact of new orders in the production planning, as represented in figure 4.

Further work will involve the refinement of the requirements and the choice of specific modelling approaches, techniques and algorithms to use in the system development.

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