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THE PRICE-DATE-RELATIONSHIP AS A NEGOTIATING TOOL IN PRODUCTION PLANNING AND CONTROL

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Market principles have long served to coordinate allocation processes on a self-organizing basis. A new approach transfers these principles to the processes in a company's production operations. The price-date relationship introduced in the following paper is a tool by means of which order management can be simplified as part of decentralized production planning and control.

1. SELF-ORGANIZED ORDER CONTROL WITH PRODUCTION AGENTS

Nowadays manufacturers are facing an environment which is becoming more and more complex. This complexity calls for new requirements in production planning and control (PPC). Consequently planning tasks are becoming decentralized to solve the problems at the point where they occur. Conventional systems for order management are no longer able to meet these new requirements. One reason for this development is caused by the resource-oriented design of conventional PPC systems. These systems are not able to take account of individual goals of a specific order like costs or target delivery dates. In case of the order management for a complex production the scheduler often does not know which criteria, algorithms or decision parameters are determining the results of the PPC-system. As a matter of fact, the acceptance of PPC-systems is coming into question. In daily business schedulers tend to manipulate PPC-systems in order to receive the desired results. Another shortcoming of centralized PPC-systems is the reaction behavior in case of disruptions in production. Disruptions caused by machine break-downs or changes in customer demand often make it necessary to reschedule the production sequence. This rescheduling is very time and cost consuming. Finally, centralized PPC-systems do not allow the evaluation of and selection between different planning

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alternatives. They do not provide information about the economic effects of orders with high or low priorities.

The Institute of Production Systems at the University of Hanover in Germany is pursuing a promising approach to developing a system for planning and control in a decentralized production environment [1;2]. With the help of so-called production agents, a self-organized production planning and control is being developed. The starting point is the decentralized units in the production department of a company. These units have certain capabilities and pursue individual objectives. Agents represent these units in computer-based production planning and control. It is assumed that each agent only represents one process step. The results of a process step are the products which its agent can produce. All agents in production act jointly together to manufacture the final products of the firm. They follow the common objective to produce all products demanded by customers on time and for the agreed price. Each agent makes its own contribution to achieve this objective. To succeed in this the agents need to be coordinated.

Regarding the order management, this coordination consists of the allocation of material and resources. The concept of the self-organized PPC transfers market principles to production so that agents have to compete with each other. This market-driven allocation forces the autonomous agents to achieve their individual objectives if they are to stay and succeed in business [3]. In such a system there is no need for a central agent, which would stall the whole production in case of its own breakdown. It is rather supply and demand which control production. Certain regulations established by the management form the internal market. The competition between single agents in this internal market leads to self-organizing allocation processes and at the same time encourages better performance as well as the continuous improvement process.

In this competition-based approach the decentralized units have to negotiate. There are units representing customers and inquiring about products and there are units representing suppliers and tendering products. Between these two principle parties, a business relationship has to be established containing the agreed delivery date, the description of the product, and the required amount.

2. CLASSIC TENDER PLANNING

The main task of an independent agent is the planning of tenders in response to inquiries from other agents. Kambartel defines tender planning as a process in which an entrepreneur prepares an individual offer for a specific customer inquiry [4]. This offer contains an individual solution for the customer, based on the product sales and the economic situation of the enterprise. It is free of charge for the customer, in the hope of a subsequent order.

This classic definition of tender planning is based on a defined inquiry from a customer asking for customer-specific products. The tender planning has to verify that the offerer is able to fulfill the requirements of the customer to his satisfaction [5]. Therefore, the following four parts of a tender have to be fixed [6]:

- Technical tender planning prepares a constructive response to the inquiry.
- Date planning determines the obligatory delivery date taking into account that other orders have already been scheduled and other tenders might be out waiting for response.
- In tender calculation expected manufacturing costs for the offered products have to be reckoned. The price for the tender has to be fixed on the basis of the costs.
- Legal conditions include the general terms of a business relationship such as warranties, conditions of payment, delivery conditions or property rights as well as a statement about the length of time the tender is valid.

The idea for the tender planning has been transferred to the decentralized PPC. Due to the internal market, technical planning and legal conditions will not be taken into account.

3. PRICE-DATE RELATIONSHIP – AN APPROACH FOR MULTIPLE TENDER

In classic tender planning a single tender with exactly one price and one delivery date will be determined on the basis of the inquiry for a certain product in a certain quantity. In most cases of complex production one agent launching an inquiry will address several offerers in order to choose the best of several offers. Every single offerer in turn has to inquire of its suppliers for necessary materials or pre-products. The negotiating between the agents becomes very complicated when a multitude of suppliers and sub-suppliers have to bargain over delivery dates over several levels in the product structure of a complex product. In principle every inquiry can be answered, but the process of receiving the tender is very slow, necessitates much communication effort, and brings along tough negotiations between agents.

To minimize the effort of communication and to speed up tender planning, this paper presents the so-called price-date relationship (PDR) as a negotiating tool. Every agent inquires not for a definite delivery date but only for a specific product in a certain quantity. The answer to such an inquiry is the PDR, which contains a multitude of price-date combinations. With the PDR the offering agent hands over the price decision to the inquiring agent. The inquiring agent can choose between different price-date combinations and select the best one for its own operation. Figure 1 shows an example of the progression of the PDR curve. This progression reflects that the customer can decide, in view of the price, when his products should be delivered. There is no longer any need for unnecessary and time-consuming negotiations about price and delivery date. Today this approach has already been implemented in the production of printed circuit boards. There the price of a printed circuit board is not fixed in general but can vary depending on the customer and his wishes concerning delivery dates [7]. In decentralized PPC this approach has been transferred to single process steps represented by agents.

In general the PDR progression curve, plotted over the delivery time, decreases exponentially. This is due to the fact that, for early delivery dates for a new offer, many other orders have to be rescheduled and necessary materials or pre-products have to be procured quickly. This results in high prices. For long delivery times the

progression curve reaches a minimal price representing the break-even point for economical agent operations.

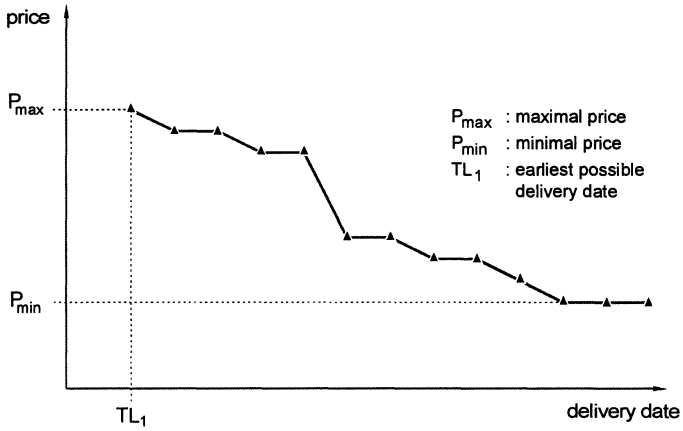

Figure 1 – Price-date relationship

4. NEGOTIATING MECHANISM BETWEEN PRODUCTION AGENTS

For agents the PDR actually extends the definition of a pure tender. The PDR not only supports it on a unique basis to receive and to win orders but also serves as a negotiating tool which can be used for disruption management in production. A PDR will be generated for every new order.

In drawing up a PDR, separate order plans have to be conducted for every point consisting of one price and one delivery date. This planning receives only limitations by the process and set-up times of orders either already or still to be scheduled. For each possible delivery date, all important time sequences have to be determined and the necessary raw materials and pre-products procured. This procurement will also be handled with the help of PDRs. For each necessary raw material the agent will launch an inquiry to several different suppliers and will receive PDRs in return. These PDRs will certainly be different, since every agent is organized differently and can already have scheduled a different number of orders. Figure 2 shows PDRs of three different agents for a quantity Y of product A. The different progression curves are depicted in one diagram. The agent can select the best offer.

With the selection of the best tender for raw materials the agent can prepare his own planning. For each possible delivery date the respective costs and tender prices can be determined.

Every point in the PDR represents a complete calculation and date planning of a new possible order. The costs and delivery dates are not only determined for the new order but for also for the changes to the already scheduled orders. Since every agent only represents one process step in production, the number of confirmed orders for one agent can easily be handled. Thus the rescheduling scenario can be generated easily and quickly. Each point in the PDR consists of one rescheduling scenario to

be established as real planning in case the customer selects this price-date relationship to confirm his order.

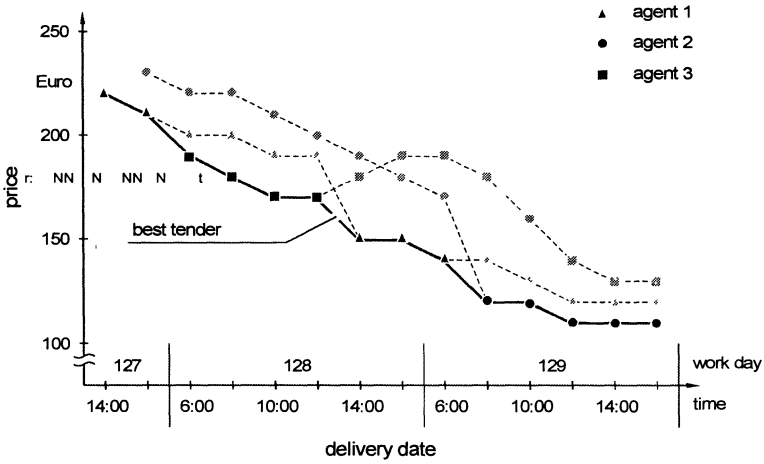

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Figure 2 – Price-date relationship of three agents

The rescheduling scenario contains the lead time elements of each scheduled order. It represents all necessary time sections of an order. In figure 3 the new order is inserted between the already scheduled orders for delivery date X. Such a scenario as depicted in figure 3 will be generated for every point in the PDR. The selection of one point, i.e. the selection of one price-date combination, means that the rescheduling scenario will replace the actual scheduling of the confirmed orders. All other agents influenced by this rescheduling process receive a failure message. The reaction to this failure message can be a new inquiry. This results in a new tender planning with the help of PDRs. The ease of PDR calculations will help to remove disruptions as soon as possible. If a rescheduling scenario is not selected it will be deleted.

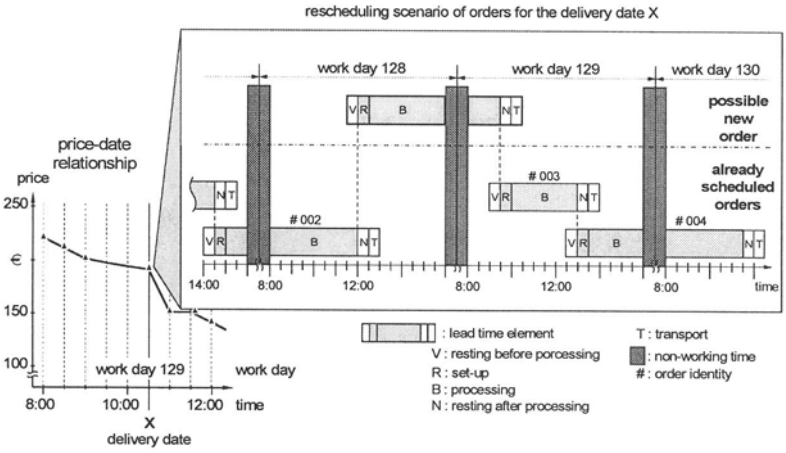

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Figure 3 – Price-date relationship as result of tender planning

5. PROTOTYPE OF A COMPUTER-BASED TEST WORKSHOP

In order to gain deeper insight into the behavior of PDRs as a negotiating tool in a decentralized PPC system, a computer-based test workshop is under development at the Institute of Production Systems. In a network of several computers, every agent is an individual server which has stored all the necessary information and processes, including a tool to calculate PDRs. The agents are interlinked over the Internet and get in contact with each other to exchange inquiries, tenders and confirmations for orders. The Internet is an ideal platform for these communication processes. It also represents a decentralized structure without a central authority, and thus reflects the aim of decentralized PPC. The first tests are currently being run and it will soon be possible to report initial findings about the performance of decentralized order management with production agents.

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