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The Shop Floor Scheduling Game

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1. INTRODUCTION

The aim of the shop floor scheduling game is getting participants acquainted with:
- developing robust planning and scheduling procedures;
- accepting orders under uncertainty and competition;
- using information from cost accounting in scheduling;
- creating an adequate communication structure within the team;
- working under time pressure.

The organization of this paper is as follows: an overview of the simulated production situation and of the constraints for the production control system is given in section 2. The game consists of 3 phases: the preparation phase is considered in section 3, playing the game in section 4 and finishing the game in section 5. In the final section attention is given to the context of this game and our experiences with the game.

2. PRODUCTION SITUATION

The operation of a small firm with 6 machines is simulated. The company consists of a job shop department with three different machines, two identical assembly lines and a painting department, as can be seen in figure 1.

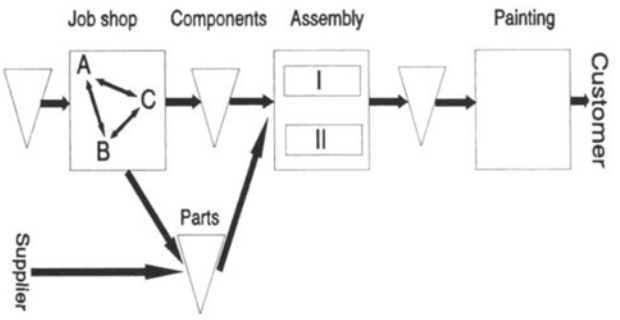


Figure 1. Simulated Production Situation

J. O. Riis (ed.), *Simulation Games and Learning in Production Management*

Production is order-based. An end product consists of common parts and special parts. The common parts are required for more than one end product. The special arts are specific for each end product. Parts are produced in the job shop department, from rough materials. For each part a routing sheet is available in which the required operations and necessary operation times are decribed. Batches of common parts are either produced inside the company or purchased from a supplier, what normally takes more time. Adjustments of capacity of the job shop are possible to a certain extent (overtime work). If all required parts are available, assembly can start.

In this make-to-order manufacturing situation there are two types of orders that can enter the system: orders that come from clients with long time contracts, so called normal orders, and quotation orders that are offered to the firm with the best proposal. The moment normal orders enter the system and the capacity requirements of these orders is not known in advance. The lon time contract states that these orders have to be delivered on time. The firm will be charged if they deliver past due, sometimes a premium is given if the order is delivered early. For orders that are quoted by and offered to the firm, delivering past due will also result in a fine.

Cost accounting information of this firm that can be of use in quoting orders is available.

There are some constraints for the production planning and control system in this firm. These constraints are translated to some simple rules for planning/scheduling, purchasing common parts and quoting orders. To give an idea of these rules, some of them are presented below in table 1. The real game situation is still more complex, especially considering overtime work and requirements on the financial reports. The complexity of the real-life scheduling situation is simulated in this way.

Table 1. Rules for the Shop Floor Scheduling Game

Rules for Scheduling

General
- In daytime 8 hours are available
- A (production)batch equals the order size

Overtime
- To a maximum of 8 hours per machine can be worked in overtime
- At the painting department overtime is not possible

Batch production
- The next operation can start as soon as all products of the batch on the current machine have finished
- At the assembly lines parallel production (at the same batch) is allowed.

Rules for purchasing parts

- The leadtime for purchasing parts is 1 day. There is no minimum order size.
- The parts can also be made in house (in the job shop department). The necessary production hours are mentioned in the initial job package. Production uses a minimum batch quantity of 3 parts per batch.
- A batch of parts that becomes available at day i can be used in assembly at day i+1.
- If assembly starts on day i all necessary parts for the whole batch have to be at the assembly line.

Rules for quotation

- The quoted price has to be based on the machine cost price and purchasing price of parts.
- The profit margin is between 50% and 150% of the calculated cost price.

3. PREPARATIONS

There are a number of tasks that have to be performed preceding the game.

First, the participants have to read the instruction material on the game. They need to learn what rules there are for planning/scheduling, for purchasing common parts and for quoting orders (see table 1). These rules have to be used in preparing an initial schedule. There are 5 normal orders that are known in advance. They are presented to the participants in a format as can be seen in appendix 1: Normal orders: Initial job package.

To obtain this initial schedule, a scheduling procedure should be designed and planning decisions on the use of overtime work and make or buy decisions have to be taken. An example of a proposed scheduling procedure that was developed by a team is given in appendix 2. Using such a procedure an initial schedule has to be constructed on a gantt-chart.

For the planning decisions the participants have to generate cost accounting information that can be used in taking scheduling decisions. They determine the rates per machine hour and decide on other information that can be used. Also

Finally, the team has to develop an inventory control system for the common parts and has to think about the different roles that need to be performed during the game, as there are planning tasks, financial bookkeeping, inventory management and quotation of orders. A communication structure in the team is needed, because during the game they have to work under time pressure and there is competition between the teams.

Preparation time for participants (teams) is about one day.

4. PLAYING THE GAME

The operation of this small firm is simulated during 5 production days. Each day the team gets new orders, has to perform schedule operations using the gantt chart, purchases common parts, creates financial reports etc. Each team gets the same normal orders at the same time. In this way the element of competition between the 4-6 teams can be used in playing the game. The effect of the planning decisions can be illustrated and the robustness and performance of the scheduling procedure can be evaluated.

The schedule is each day constructed for the next 10 days, but only the first (current) day is communicated to the supervisor. The schedule of this day is considered to be the realised production of the day, insofar that the scheduling rules have been applied correctly. This is checked by the supervisor.

One of the days a list with 10 quotation orders is presented to all teams. The teams can apply to one or more orders by stating a due date and a price for an order.

At the end of this simulated day the quotation forms are collected and a computer is used to assign each order to the team with the best offer. An impression of the computer program that assists the supervisor is given in table 2.

Table 2. Assisting computer program

Quit Costs Quotes Compare Output Parameters 11:37:14 a.m.

Group	Mach A	Mach B	Mach C	Assy(1 line)	Painting
1	63	78	69	43	70
2	53	79	64	48	72
3	64	81	70	40	72
4	60	74	65	49	66
5	63	83	70	39	73
6	60	74	65	49	66

Quoted / not quoted by group

Job	1	2	3	4	5	6
1	-	+	+	+	+	-
2	-	-	-	+	-	-
3	+	-	-	-	-	-
4	-	+	-	-	-	-
5	-	+	-	+	-	+
6	-	+	-	+	-	-
7	-	-	+	+	-	+
8	+	+	-	-	-	-
9	+	-	+	+	+	-
10	-	-	+	+	-	-

Compare quotations J.Riezebos University of Groningen

The program generates overviews per order (which teams have applied to this order and what was the best offer) and per team (what are the results on the quoted orders and why is it (not) given to this team).

Using the program the supervisor can give quick and adequate feedback to the teams on their quotation and order acceptance strategy.

At the end of each simulated day the teams produce a financial report (see appendix 3) and the financial results of the different teams are presented to all teams.

5. END OF THE GAME

The duration of the game is about half a day. The game is finished with delivering the schedule for the next week to the supervisor. The supervisors need some time to check these schedules on availability of parts etc. During this time the game is evaluated with the participants. The proposed scheduling strategies are compared with the applied scheduling procedure and the correctness and robustness of the initial procedures is discussed. For example, the proposed scheduling procedure that is presented in appendix 2 did not work, as there were mistakes in the procedure itself as well as problems with the dynamically changing environment which made a quick rescheduling procedure necessary. In this way differences between the teams are considered and the teams are asked to explain their choices.

When the results of all teams are known, the evaluation is completed with a discussion of these results.

The teams have to describe their findings in a report. In this way they are forced to rethink the procedures that were developed and gain insight in the appropriateness of these procedures in a dynamically changing complex environment.

6. CONTEXT OF THE GAME

The shop floor scheduling game is a revised version of a 5 day game developed by F. Langemeyer, TU-Eindhoven. It is redesigned for third year students in a course on operations management / production planning. Since 1988 it has been used for students Mechanical Engineering (University of Twente) in an integration course. The students have already knowledge of production planning methods, scheduling algorithms, cost accounting principles etc.

Since 1989 the game has been used at the University of Groningen in the Business Administration program, in a course on production management and in the Technical Engineering and Management Science program in a course on production control. Both type of students were already familiar with cost accounting principles and elementary production planning procedures and they had to learn to design procedures that were appropriate in a specific organizational context (the make-to-order manufacturing environment).

By playing the game students see the need for communication and coordination in a team of specialists and they get quick feedback on the robustness of the procedures they had developed. The usefulness of cost accounting information for specific decisions in this organizational context can be discussed.

The use of a computer is restricted to assistance of the supervisors. The students work with large gantt charts so they can discuss within the team the correctness of the scheduling decisions. The gantt chart is mainly used as a communication device, not as a scheduling tool. That is the reason why we do not use a computerized gantt chart. The students first have to learn what the pro's and con's are of using such a tool in an organizational context before they try to find so called optimal solutions with the use of specific algorithms.

When playing the game, each team is to be accompanied by a supervisor. One supervisor can attend at most two teams in parallel. The preparations of the participants need to be checked preceding the game, so any mistakes can be corrected, and the evaluation reports need to be criticized. As can be seen, the necessary input from staff is large.

The shop floor scheduling game is one of the most popular games experienced by our students.

Appendix 1: Normal jobs initial job package

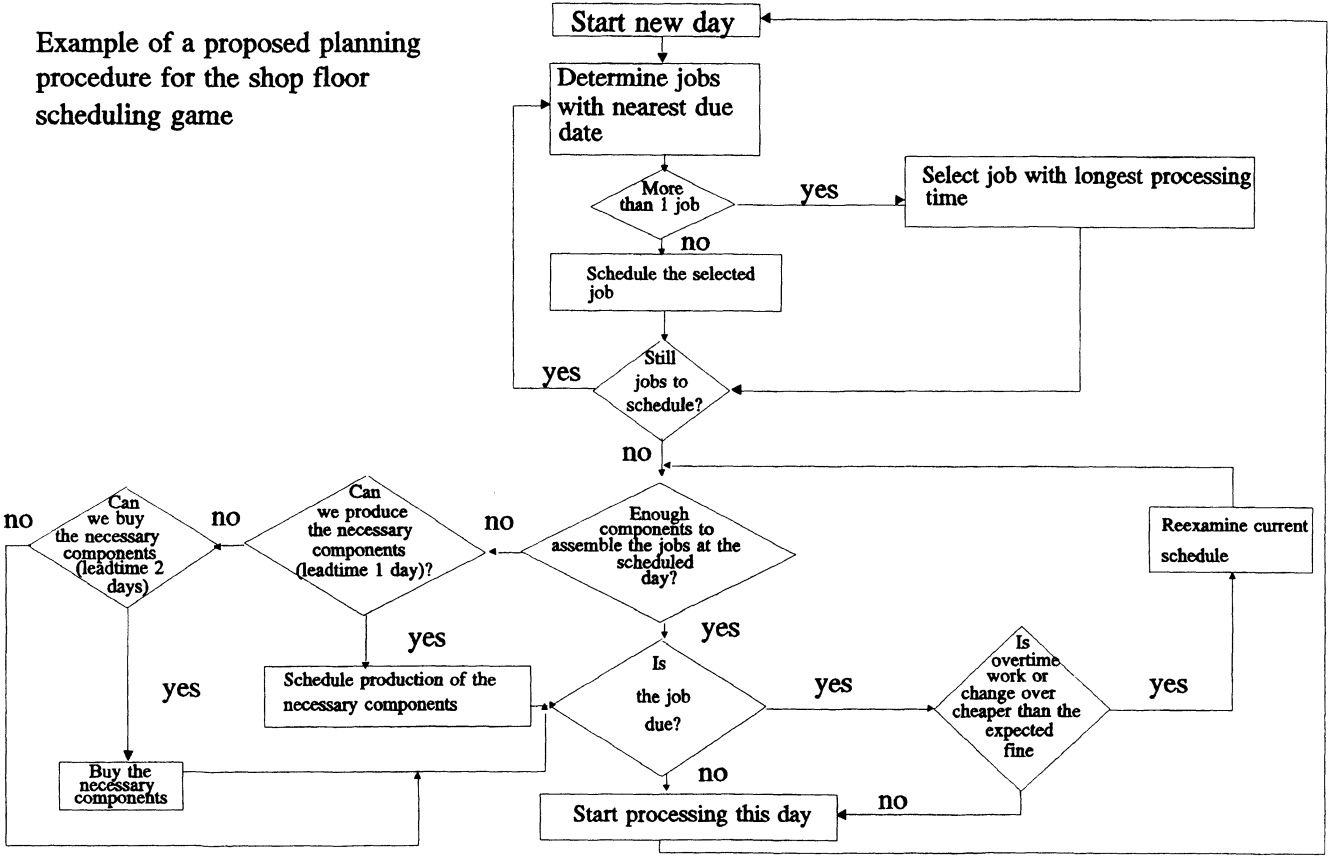
Job nr	Nr. prod.	Due date	Operation 1		Operation 2		Operation 3		Operation 4		Assembly h/st	Painting h/st	Total Sales	Total Fine per day	Total Premium per day
			Mach	h/st	Mach	h/st	Mach	h/st	Mach	h/st					
N1	2	2	B	2							4	1	1950,-	150,-	-
N2	1	2	C	3	A	4	C	1			3	2	1750,-	150,-	-
N3	3	4	B	2	A	4	C	1	B	1	5	1	4500,-	300,-	-
N4	2	5	A	2	C	3	B	2			2	1	3800,-	450,-	400,-
N5	2	8	B	2	C	1	A	3			3	1	4850,-	500,-	450,-

Part	Purchasing price	Operation 1		Operation 2		Start inventory
		Mach	h/st	Mach	h/st	
X1	35,-	C	1			3
X2	55,-	A	2			3
X3	60,-	B	1			6
X4	80,-	A	1	B	1	3
X5	20,-	A	1			3

Job nr.	Number of parts per product				
	X1	X2	X3	X4	X5
N1	1	-	2	1	-
N2	-	2	2	1	-
N3	1	-	1	1	2
N4	-	2	1	-	-
N5	1	-	-	-	2

Appendix 2: Example of a proposed planning procedure

Example of a proposed planning procedure for the shop floor scheduling game



Appendix 3. Financial factory overview (day)

Cost	Daytime			Overtime internal			Overtime external			Total
	hours	à *f*	*f*	hours	à *f*	*f*	hours	à *f*	*f*	
Machine A	8									
Machine B	8									
Machine C	8									
Assembly I	8									
Assembly II	8									
Painting	8									
Tot. hours	48									
Total *f*										

Cost of parts:

Item	Price/ item	Number	Total
X1	*f* 35,-		
X2	*f* 55,-		
X3	*f* 60,-		
X4	*f* 80,-		
X5	*f* 20,-		
		Total:	

Sales:

Job	Sales	Premium	Fine	Total
			Total Sales:	

Total result	Minus	Plus	Total
Saldo day before			
Total sales +			
Total machine costs			
Total parts costs -			
		New saldo	