AUCTION BASED PRODUCTION SYSTEM THROUGH ACTIVE DATABASE SYSTEM

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ABSTRACT

The aim of this paper is to point value of auction in distributed manufacturing system architecture. "Auction" is an interrelation of computer systems and cells, in which active database assigns certain jobs to the cells, and the cells judge their ability to do the assigned jobs with calculation of estimated machining time. The final result comes as the selection of minimum machining time by the computer system. It is efficient, for cells are given ability to estimate their possibility in achieving jobs, and therefore the total system acts pliably.

It is true that interrelation between the scheduling systems and the cells has been achieved in conventional manufacturing systems, but the systems have predominated over the actual cells. In those systems, job information has been provided by the systems and the cells have remained subordinate. However, recent advancement of the cell controllers has enabled to administer intelligent information processing even within the cells. Cell controllers may judge possibility to accomplish assigned jobs, generate operation plan, and estimate machining time.

Therefore, this manufacturing system architecture, called "auction" should play a key role in re-scheduling in order to cope with potential alteration.

1. INTRODUCTION

Levels of automation have been achieved to enhance the efficiency in production as synthesis of CAD/CAM systems, automated facilities and scheduling systems. CAD/CAM have predominated over production process, and alteration has taken place in CAD/CAM even if modification has been required in the actual production process. Therefore, this system is unprotected against potential failures, such as sudden change in production plan or failures of facilities.

In order to cope with these problems, distributed manufacturing system with the help of "auction" is effective[Arai, E., (1995)]. Some of controlling features, such as operation planning, are given to hardwares of machine tools and robots. These controllers are connected in computer networks, and specific problems are dealt in a network architecture based on active database system. Final results are given as modification of production plan through scheduling system.

2. SYSTEM ARCHITECTURE

Interrelationship between the scheduling system and the cells is vital element to achieve pliable production plans[Okuno, N., (1992)][Ueda, K., (1992)]. A case of distributed production system based on active database is shown here to explain actual procedures in assigning jobs to the cells with the help of auction(Fig.1).

The core part of this renovating system is the combination of communication controllers and job/cell databases in a network system. The job database stores the production requirements, and the cell database stores the functionality and the current status of machining cells that is kept updated.

In a surrounding area, production scheduling system and CAD/CAM systems are connected to the core part. (Material handling system is not considered here).

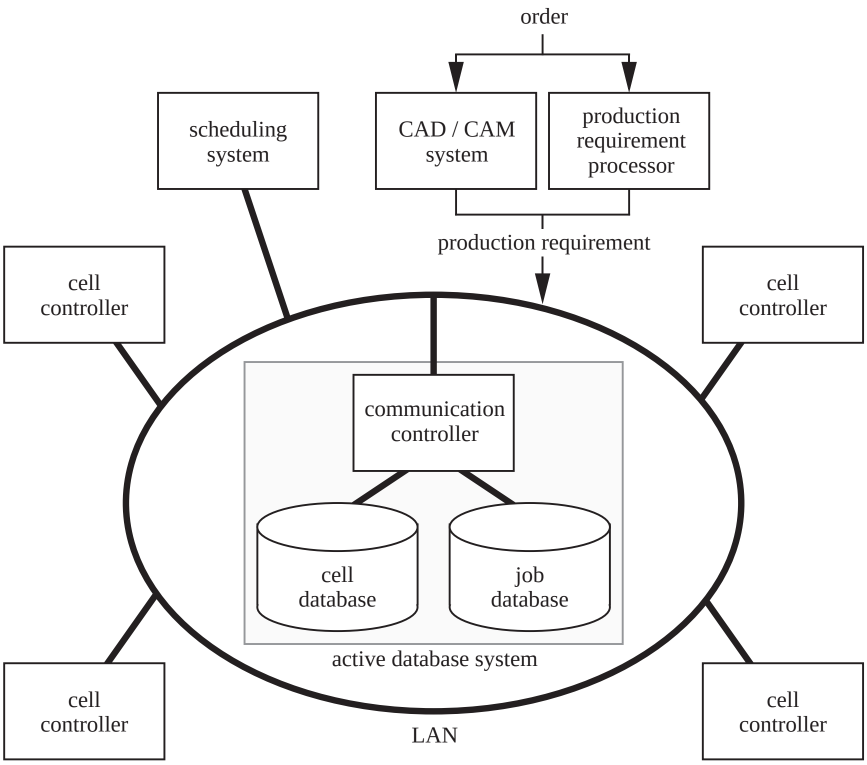


FIGURE 1 : AUCTION BASED SYSTEM ARCHITECTURE WITH ACTIVE DATABASE

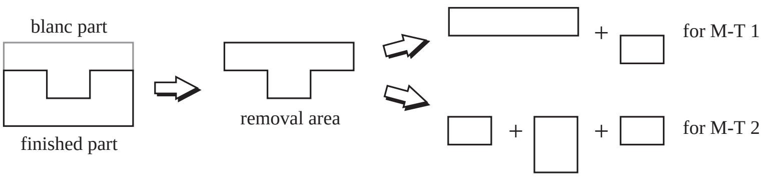


FIGURE 2 : DIFFERENT OPERATIONS FOR THE SAME REMOVAL AREA

Actual machining cells are connected also in this surrounding area. Generally production of parts requires specification of kinds and numbers. (Due dates are not considered at this point.). Details of parts are described in the CAD system using machining features with procedure constraints extracted through recognition process in the CAM system[Ranky, P. G., (1992)][Kjellberg, T., (1991)]. Functionality of machining cells are characterized by feature classes, accuracies and maximum dimensions, and they are kept updated through the network. These informations are the basis for the auction.

Therefore, at this point "auction" plays an important role. For one assignment of carving, for example, various operation plans may be presented (Fig.2), but intelligent machining cells can make their own operation decisions by selecting the most suitable. Definite production requirements are transmitted to the job database when they become determined.

3. PRODUCTION SCHEDULING

Production schedule must be pliably altered when "triggers", or modifying elements, are found[Takata, M., (1995)]. In active database, triggers are changes in production plans, and in cells they are changes in functionality, such as failures, recovery or renewal.

When modification is needed, active database immediately transmit the necessary data of machining features of parts that are to be completed, to the selected cells based on information in cell database. Each cell judges the machining possibility, generates operation plan by selecting the most suitable set of features, and calculates the machining time for each removal area[Iriguchi, K., et al., (1992)][Adams, K. G. and Huang, S. H., (1992)]. (For this stage, detailed operation planning is necessary, but in this paper, calculation are based on the cutting performance which is predefined in each cell.)

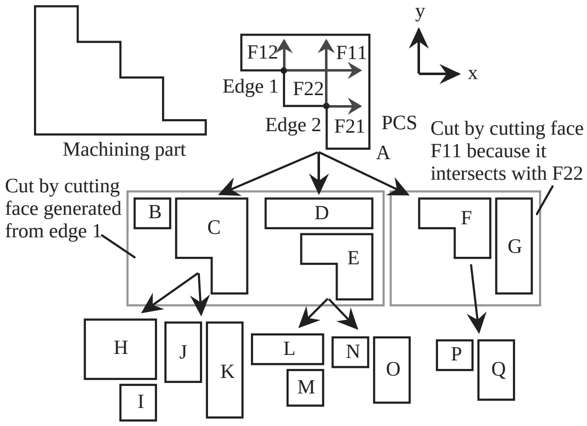


FIGURE 3 : AN EXAMPLE OF DECOMPOSITION

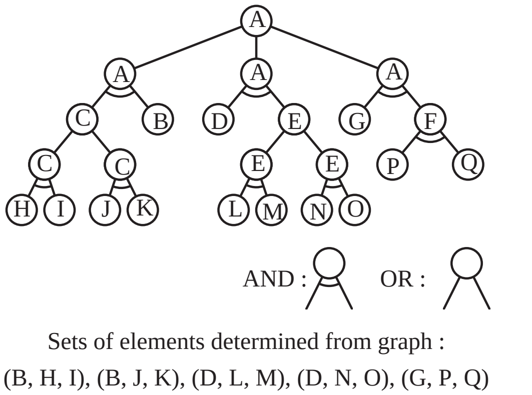


FIGURE 4 : AND-OR TREE REPRESENTING DECOMPOSED ELEMENTS

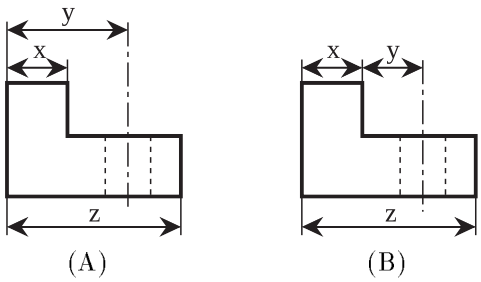


FIGURE 5 : TWO DIMENSION DESCRIPTION OF THE SAME PART

At this point, "auction" of several consecutive phases takes place, and each phase corresponds to respective removal area. Active database collects the replies, and at each phase probable cells are selected and sent to the scheduling system. After reviewing all necessary phases, selected cells are determined and interwoven into production schedule.

It is necessary to mention here that as a scheduling rule, simple SPT is used here for faster calculation. Re-calculation is frequent,because changes in plan, facility, functionality require flexible production schedule.

4. FLEXIBLE MACHINING FEATURES

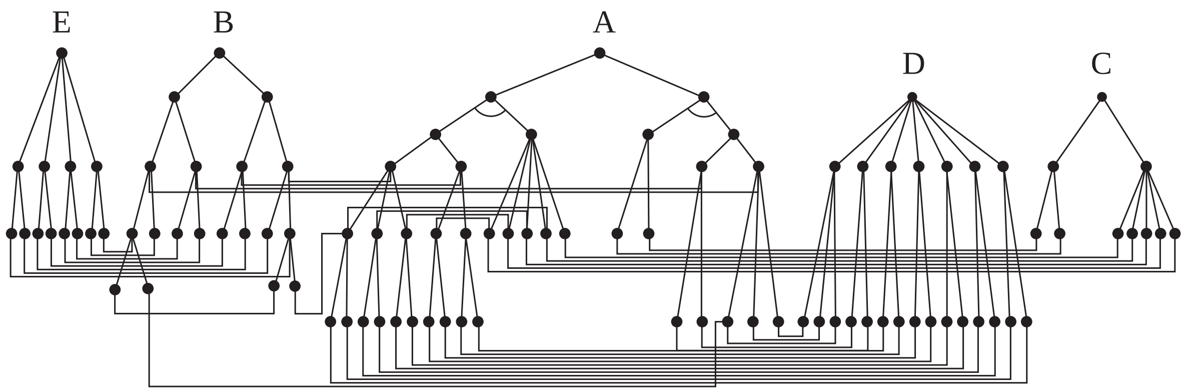
As described in the Section 2, part geometry is characterized by several feasible sets of machining features. In this section, this process is elaborated by showing actual procedure that takes place in CAD/CAM systems[Chang, T. C., (1991)][Arai, E., et al., (1994)].

First, the removal area is computed by making the difference between the blank material and the finished part. The removal area that is composed by the planes and cylinders is decomposed by the cutting planes that are generated referring to the kinds of edges; concave and convex edges.

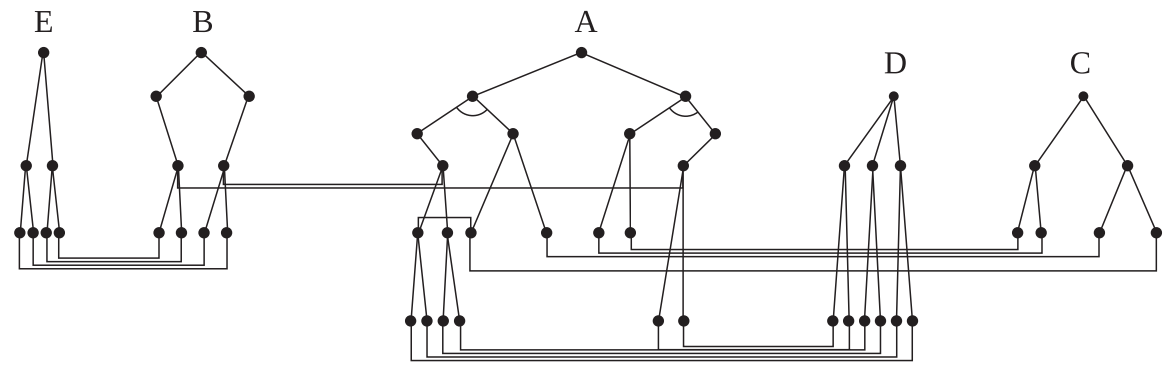
From any edge, cutting faces can be generated by sweeping the edge along the sweeping directions. The sweeping direction of the edge can be found from the direction of the coordinate system of finished part given by the user. The two connecting faces on the edges considered to generate the cutting face must be plane-plane faces or plane-cylindrical faces. Edges that connecting faces on them are cylindrical faces will not be considered to generate any cutting faces here. The number of generated cutting faces depends on the edge types and the direction of the coordinate system.

An example of this decomposition process is shown in Figure 3. Decomposed removal area can be presented in the And-Or graph such as shown in Figure 4. And nodes in the graph show the decomposed elements. Or nodes show both the resulting of the decomposition and the copy of decomposed elements used in the decomposition process. Leaf nodes in the graph show all decomposed elements found from the root nodes.

Designers can represent their intention about machining parts by use of several types of descriptions such as tolerance and dimensions. Figure 5 show the two dimension descriptions of the same part. In



(A) ORIGINAL AND-OR GRAPH



(B) SIMPLIFIED AND-OR GRAPH

FIGURE 6 : TWO AND-OR GRAPHS OF DECOMPOSITION

Figure 5 (A), it is shown that the hole or slot can be machined without regarding about their machining order because their specifications or positions in the part do not relate with together. But in Figure 5 (B), the hole should have to be machined after the slot because the position of the hole is shown by relating with a face in the slot.

Since the dimension descriptions of machining parts represent both the specification of parts and the machining orders among machining features in parts, the constraints of machining order considered here as the design intention constraint.

The precedence constraints among machining features can be derived by geometric interference that is detected in the geometric modeling system and attached attributes such as surface roughness.

With taking the precedence constraints into consideration, the number of feasible sets of machining features is reduced, for instance And-Or graph for Figure 5 is simplified as Figure 6. Several sets of machining features for one removal area are generated from the And-Or graph, and are used to present the part shape in the job database.

5. CASE STUDY

For more apprehension, in this section a production system with five cells is taken as an example.

When production requirement as Figure 7 is given, production schedule shown in Figure 8 is generated after executing auction by the active database. Figure 9 shows the result of re-scheduling when one cell fails. This process is caused by a "trigger", a report of failed cell. Figure 10 shows the cell data.

6. CONCLUSION

In this paper, usability of "auction" in a distributed production system architecture has been discussed. Auction is valuable, for systems can pliably modify the production schedules against various changes in actual production processes. This process will increase ability in production in more flexible ways.

Part ID	Material	Process No	Feature type	Precedence	Volume	Accuracy grade
1	S45C	1	1		300	
			2		600	
			3		240	3
			1		300	
			2		840	3
			1		400	
			3		740	3
		2	1		480	
			2		300	
			3		600	4
			1		480	
			2		900	4
			1		680	
			3		700	4
		3	1		420	
			2		180	
			3		240	
			4		420	3
			1		420	
			2		420	
			4		420	3

FIGURE 7 : JOB DATA EXAMPLE TO SHOW PRODUCTION REQUIREMENT

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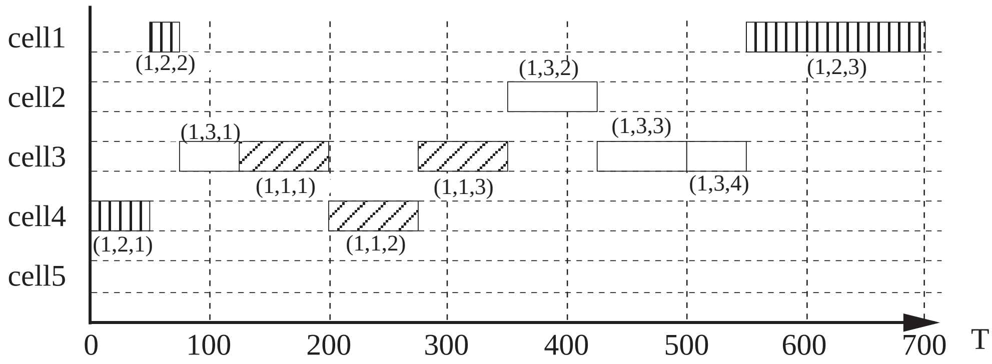

FIGURE 8 : SCHEDULING EXAMPLE FOR ONE PART

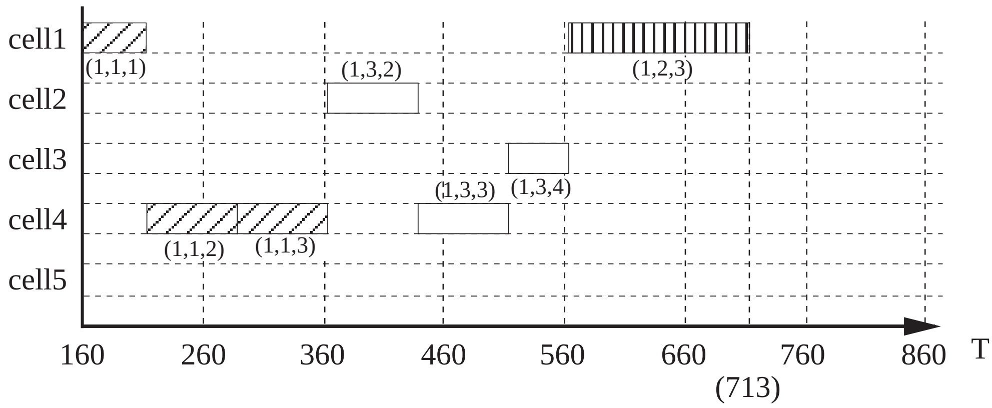

FIGURE 9 : RE-SCHEDULING AGAINST FAILURE OF CELL 3 AT $T = 160$ AND RECOVERY AT $T = 460$

Cell No	Status	Possible machining features	Maximum dimensions	Performance (cutting volume / min)
1	BUSY 30min	TYPE 1 TYPE 2 TYPE 3 TYPE 5 TYPE 6	30×50 30×30 10×10 20×30 20×30×50	0.04 0.2 0.08 0.6 1.2
2	FREE 5min	TYPE 3 TYPE 4 TYPE 5 TYPE 6 TYPE 8	10×10 40×80 30×30 30×30×50 20×20×20	0.05 0.4 0.7 1.0 0.08
3	BUSY 25min	TYPE 1 TYPE 2 TYPE 3	40×60 30×40 20×20	0.03 0.18 0.11

FIGURE 10 : CELL DATA EXAMPLE