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Opportunistic coordination of operations in job shop production

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Abstract

The starting point of this article is production planning and control (PPC) in job shop production, i.e., processing units in a job shop are investigated executing different operations on part types. In this context, the problem is to allocate the single operations of production orders to processing units with respect to the underlying objectives. PPC systems, however, fail to incorporate the knowledge of production-related theory and tend to be based on relatively simple heuristics (see Steven, 1999, p. 319). This means that the inherent flexibility of a production system will largely be ignored. Existing PPC systems, thus, show a clear theoretical deficit. Given this background, the article aims at

- integrating production-related theory more strongly into the world of PPC, and
- exploiting developments in the area of distributed problem solving.

Keywords: Production planning and control; Scheduling; Multi-agent system

1. The concept of opportunistic coordination

Job shop production is a special organisational form of production in which machines carrying out identical or similar operations are combined in one job shop. In order to perform these tasks, part types are brought to the job shop in a pre-determined sequence, in the course of which a part type can pass through the job shop more than once. Because of its *high level of flexibility*, the organisational form job shop production is generally chosen when

- the production plan incorporates a large number of different product types,
- the production includes relatively small quantities combined with very different working cycles, and
- demand displays relatively strong fluctuation over a certain period of time.

These conditions are particularly prevalent in *order-driven production* of single or small batches.

From this scenario we can derive the *conditions for production planning and control*. They are largely based on

- the *extensive scope of action* within job shop production together with
- the relevance of *time-related, open decision fields* (see Schlüchtermann, 1996, p. 2) due to the random arrival of client orders and the unexpected occurrence of disturbances.

The concept of opportunistic coordination continues from these aspects and attempts to exploit the inherent flexibility of the production system in order to compensate the negative effects of unexpectedly occurring changes.

Our starting point is the theory that a production process is subject to uncertainty. This uncertainty is ultimately reflected in disturbances carrying the risk that a conceptual production plan cannot be implemented. For this reason, opportunistic coordination dispenses with the creation of plans in the traditional sense (see Zelewski, 1995, p. 296). Its basic *principles* are (see Corsten

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Nomenclature

Parameters

Ag: agent
B: binary preference variable
BF: break function
BS: break/shift model
BU: budget
c: cost-rate
C: cost
d: duration
NP: negotiation points
O: production order
OAg: order agent
OP: operation
P: price
PAg: processing agent
PM: processing alternatives matrix
PO: processing offer
PP: production plan
PR: processing request
PU: processing unit
rC: cost ratio
rd: duration ratio
SF: shift function
T: fixed date
TOL: tolerance level
U: number of alternatively executable operations/ processing offers of the processing unit/ processing agent
V: number of alternatively executable operations/ processing requests of the order/order agent
w: probability
x: lot-size
Z: profit
Δd: deviation from agreed processing time
λ: intensity
Λ: intensity matrix
σ: standard deviation

Indices

br: break
f: operations in a production plan (f=1,…,F_p)
j: production order (j=1,…,J)
m: processing unit (m=1,…,M)
o: operation (o=1,…,O) in the production system
p: product type (p=1,…,P)
s: alternative processing unit (s=1,…,S)
sh: shift
t: point in time
u: alternatively offered operation (u=1,…,U)
v: Alternatively requested operation (v=1,…,$V_{j.t}$)
y: processing offer (y=1,…,Y)
z: processing request (z=1,…,Z)