Scheduling with Fuzzy Methods

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Abstract. Nowadays, manufacturing industries – driven by fierce competition and rising customer requirements – are forced to produce a broader range of individual products of rising quality at the same (or preferably lower) cost. Meeting these demands implies an even more complex production process and thus also an appropriately increasing request to its scheduling. Aggravatingly, vagueness of scheduling parameters – such as times and conditions – are often inherent in the production process. In addition, the search for an optimal schedule normally leads to very difficult problems (NP-hard problems in the complexity theoretical sense), which cannot be solved efficiently.
With the intent to minimize these problems, the introduced heuristic method combines standard scheduling methods with fuzzy methods to get a nearly optimal schedule within an appropriate time considering vagueness adequately.

1 Introduction

Scheduling is a fundamental part of production planning and control. The task of scheduling is the allocation of activities over time to limited resources, where a number of conditions must be preserved. Resources represent objects, which can be allocated by activities. Using ordered sequences of activities, basic production flows can be specified. These sequences, which are mainly predetermined by technical or organizational requirements, are specified by jobs. Jobs can also specify supplementary conditions, as for example deadlines. In manufacturing, a job usually models an order.

2 Basic Approaches

Before the method presented in this paper is sketched, the fundamental basic approaches are considered which led to its development.
At first, reasons for conceptualizing the method as heuristic are given (Section 2.1). After showing that the consideration and processing of vague data, conditions and objectives are necessary (Section 2.2), it is shown how the integration of such information can by achieved in a common way (Section 2.3). Using this potential, it is also possible to integrate varying, partly vague conditions into the scheduling process (Section 2.4). Based on this possibility of integration, allocation recommendations can be derived (Section 2.5) which can be finally transferred into an allocation decision (Section 3.6).

2.1 Usage of a heuristic method

Nowadays, many manufacturing industries are confronted with large variety in jobs and activities whose processing can be very complex to coordinate or schedule. In practice, the determination of optimal schedules normally leads to NP-hard problems in the complexity theoretical sense, for which no efficient algorithms are known [3]. Nevertheless the theoretically optimal schedule has mostly only a short time of validity [5].
Considering the cost-benefit calculation, it is advisable to use a heuristic method generating an approximately optimal schedule in appropriate time.

2.2 The necessity for integration of vagueness

The considered input variables and parameters in scheduling – such as times, lengths of times, quantities and restrictions – usually possess an inherent vagueness [5]. Often, sharpened data is not available or can only be expensively acquired. In addition, dependences between relevant variables are only known approximately [2].
As a rule, there is a continuous transition between permissible and non-permissible conditions [9]. Frequently this fact is ignored [6]. Instead vague data or conditions are often sharpened artificially. However, artificial sharpening of data or conditions should usually be advised against. An artificial sharpening leads sometimes to a distorted image of the reality. In the worst case this leads even to a complete loss of reality [7]. Since it is closer to reality, the consideration of vague information is better than the consideration of artificial sharpened information [6].
As logical consequence, it is necessary to integrate the vagueness of naturally vague information into the scheduling process.

2.3 Integration of vagueness with fuzzy methods

Naturally vague information conveys in their basic form (but also in a nearly basic form) a more exact conceivability of its accuracy than in an artificially sharpened form. It usually can be assumed that the scheduling results will be more realistic when using information with a form as close to its basic form as possible [9], [6].
A computer-aided interpretation and processing is only attainable if the underlying modeling and processing are both well defined and equally suitable for sharp and for vague information. Vagueness must be processed precisely. For this reason, both the modeling language and the kind of processing must be from a strictly mathematical nature. As a premise, both high comprehensibility and transparency of decision must be ensured [5].
In this context, the fuzzy set theory is particularly suitable. With the fuzzy set theory it is possible to map and precisely process both sharp information and not exact quantifiable information (and vague information respectively) in a uniform way [5].