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The application of computerized production control systems in job shop environments

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Abstract

Job shops are the most perplexing and challenging of environments for computerized scheduling systems. Some vendors call them problematic and avoid them whenever possible. The development of a generic scheduling tool that can be widely installed has eluded the many vendors who have tried. Installations in job shops are still painfully slow and are heavily customized. The wide variety of types of industry and processes found in the job shop category explains part of the problem. However, there is an additional challenge facing a scheduling tool after it has been installed: will it be used and does it really help the scheduler do the task of scheduling? Is the tool used for rough planning in the next few days or is it really used for dispatching on the fly by the people sequencing work? Few studies have looked at these issues and vendors are not willing to share this information. Furthermore, few customers who have invested significantly in the purchase and installation of a scheduling tool perform an unbiased postmortem or will share the results. In this study, we will present two field studies where computer scheduling aids were considered and discuss the requirements that will support the scheduler in the daily dispatch task. We have found that while analytical and algorithmic aids have limited benefits to a typical job shop, the appropriate use of computer technology can address information overload, cue filtering, and assist the scheduler in problem solving. We describe seven steps of the job shop scheduling task and the implications of each.

Keywords: Computerized production control systems; Job shop; Scheduling tool

1. Introduction

''*In recent years the mode of computer utilization has entered a new era where meaningful interaction has been achieved between the user and the computer. This approach has been particularly effective in solving ill-structured problems. In the interactive environment the person can replace some of the programming logic with his insight and experience. In this way the analyst becomes part of the solution-decision loop and he has a better control over unanticipated situations in arriving at a solution*'' [8].

Written over two decades ago, the authors were describing the potential to be gained by supporting job shop schedulers via interactive scheduling tools. They showed that test subjects using an interactive system were able to create better schedules compared to a traditional dispatch heuristic when the problems had balanced loads and a wide variation in processing times. Unfortunately, the optimism voiced

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by the authors about the future of man-computer systems using OR and AI techniques has not translated into reality [11,21]). The task of detailed production control at a scheduler's desk remains an enigma.

In this paper, we will focus on this enigma: releasing work into the factory, determining sequences, and figuring out what to do next — where. We will not address the larger problems of order acceptance and supply chain balancing nor the specialized areas of continuous flow manufacturing, just-in-time, process industries, or the 'single large machine' problem. We will look at the Achilles' heel of scheduling: the dynamic job shop where there are many machines, many products, and orders arrive as 'jobs' with quantities, requirements, and due dates attached. The most extreme job shop in terms of uncertainty builds new products constantly and basically sells its processing capability — ''We can weld or fix anything''. The most stable job shop builds stock items but in an intermittent fashion. Between the two are a wide variety of manufacturing profiles which makes talking about the general 'job shop problem' very ambiguous. What happens in an intermittent job shop building a stable and mature product after several years of production is dramatically different from what happens in a 'prototype' job shop or a job shop facing rapid changes in materials, processes, and product design. Obviously, not all job shops have the same production control problem and not all job shops require the same solutions. Some shops may be easily managed via humans without the need of computerized systems while others are prime candidates for the use of technological aids. The questions addressed and discussed in this paper are:

- Under what conditions are humans the best choice for performing the production control task?
- Under what conditions is a human–computer solution preferred?
- If a human–computer solution is warranted, then what are the tasks the human does and what can the computer do to help?

To address these questions, the authors will rely upon two field studies involving intermittent job shops. In one field study, the human scheduler did an excellent job without the aid of technology. In the other, the human scheduler required a computer system to help manage the situation. The authors had several years of contact with each shop and developed an intimate understanding about the problem faced by the schedulers and how they tackled the problem facing them. The computer system used by the second site was written by one of the authors. Section 1 presents a brief overview of research involving the human scheduler. Section 2 introduces the two field studies and describes the production control situation in each. Section 3 compares the two sites and discusses the differences and similarities between the two. Section 4 presents a general discussion about the key issues relating to automated schedule generation. Section 5 presents the requirements for a hybrid approach to the problem. Section 6 concludes with a description of a system designed to address the key issues.

2. The human scheduler

Research on the human scheduler has been relatively non-existent compared to the vast number of papers written about scheduling heuristics and schedule optimization [7,17,21]. The limited utility of myopic and restricted dispatch rules has been often commented upon (e.g., Ref. [3]) and this has driven some researchers to consider the human component. Sanderson [18] presents an excellent review of research on the human scheduler up to the late 1980s and while a dozen or so studies were cited, one would expect more. If the studies noted in Sanderson are reflected upon, almost all focussed on how well the scheduler performed compared to how the scheduling researcher thought the scheduler should be doing their job. The studies did not specifically look to see what the scheduling problem was or what the scheduler did as a complete scheduling task, but gathered the necessary job data and compared how the scheduler would have fared against SPT, and other scheduling rules. In short, the studies did not view scheduling as a cognitive skill but as a computerized sequencing skill. This view is consistent with the traditional perspective that the theory of scheduling is equivalent to the theory of sequencing [4]. Many of the studies noted by Sanderson appeared to