Improving workload control order release: Incorporating a starvation avoidance trigger into continuous release

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\begin{abstract}
Order release is a key component of Workload Control - a production planning and control system that aims at balancing workloads across workstations, while ensuring the timely release of jobs (or orders) to the shop floor in order to meet due dates. Several release methods have been proposed and evaluated in the WLC literature. A major criterion to distinguish between release methods is whether they take the release decision at periodic time intervals or continuously. This paper aims at improving WLC order release by incorporating a starvation avoidance trigger into continuous release. Using simulation, we demonstrate that significant performance improvements in terms of mean tardiness and standard deviation of lateness can be obtained. These results are expected to have important implications for industrial practice and for future research on WLC.
\end{abstract}

1. Introduction

Global competition and changing customer requirements pose major challenges on small and medium sized companies that often produce-to-order. In order to remain competitive, companies need to simultaneously reduce the time it takes to manufacture and deliver products to customers, while realizing high delivery reliability. One means of achieving this is improved Production Planning and Control (PPC).

Workload Control (WLC) is a PPC system specifically designed for make-to-order production (Stevenson et al., 2005) that attempts to overcome the quandary of increasing delivery speed while maintaining and possibly improving delivery reliability. WLC is based on the concept of input/output control (Wight, 1970), where the input rate of work to the shop is controlled in accordance with the output rate. One of the key decision levels within WLC is order release (Land and Gaalman, 1996; Kingsman, 2000; Land, 2006). Jobs or orders are not directly released to the shop floor but withheld in a so-called pre-shop pool, from where they are released, i.e. moved into production, to meet certain performance targets. Order release aims to control the workload levels in the shop and balances the workload across workstations, thus reducing and stabilising shop floor throughput times. Stabilised shop floor throughput times, in turn, enable to quote shorter and more reliable delivery dates (Land and Gaalman, 1996; Breithaupt et al., 2002).

Several release methods have been proposed in the WLC literature (for a review see e.g., Land and Gaalman, 1996, Bergamaschi et al., 1997, Fredendall et al., 2010, Thürer et al., 2014). A major criterion to distinguish between release methods is whether they take the release decision - the decision on which jobs should enter production – at periodic time intervals or continuously, i.e. at any moment in time (Sabuncuglu and Karapinar, 1999, Thürer et al., 2012). Periodic release methods typically apply an upper workload limit, i.e. jobs are only released if they fit a certain workload norm imposed across workstation (Bechte, 1988; Wiendahl, 1995; Perona and Portioli, 1998; Cigolini and Portioli-Staudacher, 2002; Land, 2006). This creates a mix of jobs released to the shop floor that levels the workload across resources. However, it suffers from two weaknesses: (i) periodic release does not react if the buffer of work in front of a workstation is depleted in between releases, leading to premature workstation idleness; and, (ii) the upper bound may introduce further premature workstation idleness (Kanet, 1988; Land and Gaalman, 1998), i.e. work is withheld in the pool (due to the workload situation at another workstation) although the workstation is starving. On the other hand, continuous release methods are typically based on the re-order point methodology and release new work to the shop floor whenever a certain lower limit is
2. Literature review and development of new release method

This section is structured as follows. Section 2.1 first introduces periodic release methods before continuous release methods are introduced in Section 2.2. Literature is then assessed and the new release methods introduced in Section 2.3.

2.1. Periodic order release

Periodic WLC release methods keep the workload $W^S$ released to a workstation $S$ within limits or norms by selectively releasing jobs. While different periodic release methods have been presented in the literature, the release procedure executed across the methods is similar. It can be formulated as follows:

1. All jobs in the set of jobs $J$ in the pre-shop pool are sorted according to a given pool sequencing rule.
2. The job $j \in J$ with the highest priority is considered for release first.
3. Take $R_j$ to be the ordered set of operations in the routing of job $j$. $R_j$'s processing time $p_i$ at the $i$th operation in its routing – corrected for workstation position $i$ – together with the current workload $W^S$ at workstation $S$ (corresponding to operation $i$) fits within the workload norm $N^S_i$ at this workstation, then the job is selected for release. That means the job is removed from $J$ and its load contribution is added to the existing workload of workstation $S$, i.e., $W^S = W^S + \sum p_i$.
4. Otherwise, the job remains in the pool and its processing time does not contribute to the workstation workload.

2.2. Continuous order release

In contrast to periodic methods, ‘classical’ continuous order release methods do not apply a workload norm (upper bound); instead, a workload trigger is used. For classical continuous release methods, a critical workload (lower bound) is determined, which, if violated, triggers the release procedure, thereby pulling jobs from the pool onto the shop floor until the critical workload is no longer violated. This may allow the next job to be selected even if its workload means the critical workload is exceeded, i.e., there is no maximum workload constraint. Order release methods of this type can best be classified according to the workload used to trigger the release: bottleneck, workstation or shop load.

A different type of continuous release methods that apply a workload norm (upper bound) has recently been presented in the literature (see, e.g., Fernandes and Carmo-Silva, 2011a, 2011b). These release methods execute the release procedure described in Section 2.1 continuously, whenever a new job arrives to the system or an operation is completed. er et al., (2014a) recently demonstrated the potential of this new breed of continuous release methods to outperform ‘classical’ continuous release methods.

2.3. Assessment of the literature and new release methods

Periodic WLC release methods (as described in Section 2.1) provide unique workload balancing capabilities that makes them suitable for high variety contexts. However, they suffer from two weaknesses: (i) periodic release does not react if the buffer of work in front of a workstation is depleted in between periodic releases leading to premature workstation idleness; and, (ii) the upper bound may introduce further premature workstation idleness. None of these weaknesses applies to ‘classical’ continuous release methods as described in Section 2.2, but these ‘classical’ continuous release methods lack load balancing capabilities (Germs and Riezebos, 2010; Thürer et al., 2012a). The new breed of continuous release methods that uses an upper workload limit provides load balancing capabilities and has been shown to outperform ‘classical’ continuous release methods (Thürer et al., 2012a). However, while these methods address premature idleness caused by the periodicity of releases they still suffer from the weaknesses of the periodic methods.
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