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Estimating flowtimes and setting due-dates in complex production systems

STEPHEN R. LAWRENCE

Campus Box 419, School of Business and Administration, University of Colorado, Boulder, CO 80309-0419, USA

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This paper presents a methodology for estimating flowtimes and setting due-dates in complex production systems. This is accomplished by modeling flowtime estimation as a forecasting problem, and using the empirical distribution of forecast errors to set job due-dates in production settings with multiple workcenters, multiple servers, feedback queues, and machine breakdowns. Several due-date performance objectives are considered, including cost minimization, attainment of service level targets, and minimization of mean absolute lateness and mean squared lateness. Simulation experiments demonstrate the effectiveness of the method in comparison with both theoretical and empirical methods previously introduced in the literature.

1. Introduction

One of the important problems in production scheduling is setting and meeting attainable due-dates for arriving orders. On-time delivery is consistently identified as among the top two or three competitive capabilities desired by manufacturing managers in Europe, Japan, and the United States (Kim and Miller, 1992). Although sometimes imposed on the producer by an external or internal customer, due-dates or promise dates are often the subject of negotiation between customer and producer. This is particularly true in job-shop settings where a large variety of products are manufactured at infrequent intervals. In this era of shrinking inventories, reduced vendor bases, increased product variety, and 'just in time' manufacturing, the importance of quoting accurate leadtimes, setting realizable due-dates, and meeting those due-dates has grown substantially.

In this paper we develop an effective, efficient, and robust method for estimating flowtimes and setting due-dates in complex, dynamic production environments. This methodology allows a choice between several due-date performance objectives, and admits the inclusion of relevant costs associated with setting due-dates as required. It has parsimonious data requirements and is computationally undemanding. Finally, the methodology does not require the ideal of a 'steady state' system and can adapt to changing shop conditions over time.

We approach the estimation of flowtimes as a forecasting problem, and use the empirical distribution of forecast errors to set job due-dates to meet one of several objectives, including the minimization of mean absolute lateness, mean squared lateness, cost minimization, or attainment of service level targets. The methodology introduced is general and can be used in such diverse production settings as flow-shops, job-shops, and central-server shops, and can accommodate facilities with multiple workcenters, multiple servers, feedback queues, and machine breakdowns. In general, our results compare favorably with theoretical results where they are available, and substantially improve on the results of heuristic methods previously examined in the literature.

The remainder of this paper is organized as follows. The next section outlines previous research addressing flowtime estimation and due-date setting, and shows how this paper serves to combine two major streams of this research. Section 3 describes how forecast error distributions can be estimated and used to set attainable due-dates. Section 4 applies the method to a simple single-server workstations with known characteristics. Section 5 generalizes the method to simple networks of multiple workcenters. The method is applied to several hypothetical production networks and to a complex production network taken from industry in Section 6.

2. Background

Interest in leadtime estimation and setting production due-dates has accelerated in recent years. A recent and complete review of this literature is provided by Cheng and Gupta (1989), so we discuss only that research that has had a direct influence on this paper. In particular, we focus on dynamic production settings in which jobs continually arrive for processing over time, as compared with static production settings where a fixed set of jobs is