ANALYTICAL MODELS FOR MULTI-PRODUCT SYSTEMS WITH PULL TYPE MATERIAL CONTROL STRATEGIES

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ABSTRACT

Competitive pressures are forcing manufacturing companies to find new ways to provide a wide variety of products at reduced costs. Pull type material control strategies that make efficient use of available production capacities and optimize inventories could be very useful in improving factory operations. However, there is a need for analytical tools that precisely model the operating characteristics of multi-product pull systems. Such models should not only provide reasonably accurate performance estimates but also be amenable to rapid analysis of performance tradeoffs. This thesis develops an analytical approach to solve multi-product systems with pull type material control strategies.

Analytical models of multi-product systems with pull type material control strategies are composed of closed queuing networks with fork/join synchronization stations. Under general assumptions, these queuing networks do not have product form solutions and are therefore hard to analyze exactly. Consequently, approximation methods must be used for performance evaluation. This research proposes a new efficient approach based on the parametric decomposition method. The proposed algorithm yields estimates of performance measures like throughput, mean queue lengths and mean waiting times.

First, this thesis develops an approach to analyze multi-product pull systems with general manufacturing characteristics. A parametric decomposition based approach is developed to obtain performance measures of interest. Subsequently, the approach is extended to systems with batch size constraints at the manufacturing stations. These models are used as building blocks to analyze a manufacturing system where products undergo processing in multiple stages. Finally, the approach is extended to analyze pull systems that integrate information about future demands from customers. Numerical studies indicate that the proposed methods are computationally efficient and yield fairly accurate results when compared to simulation.

In addition to developing new analytical models, this research also provides answers with respect to the several tradeoffs of practical relevance. The effect of product variety and the bottlenecks in terms of service time and variability on the performance measures of the system is studied. In addition, the effect of batch size variation on the performance measures is analyzed and the tradeoffs with respect to product variety and loop length in a multi-stage system are explored. Further, the effect of integrating ADI on the performance of pull systems is also studied.