Performance evaluation of a decoupling inventory for hybrid push-pull systems.

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Abstract

Nowadays, companies that offer product variety while maintaining short lead times and competitive quality and cost, gain a competitive edge over their competitors. Therefore, hybrid push-pull systems allow for efficiently balancing lead times and production costs. Raw materials are 'pushed' into the semi-finished good warehouse and customers 'pull' products by placing orders. As performance of the decoupling stock is critical to the overall performance of the manufacturing system, we define and analyse a Markovian queueing model with two buffers, thereby accounting for both the decoupling stock as well as for possible backlog of orders. In particular, our study assesses the effect of variability in the production process and the ordering process on the performance of the decoupling stock.

Keywords: decoupling point, inventory control, Markov process and performance evaluation

Introduction

As a means to respond quickly to growing variety, shorter product life cycles while keeping inventory costs as low as possible, hybrid push-pull systems are introduced [3]. Indeed, the integration of both pure push (i.e products are stocked in advance) and pure pull (i.e. products are manufactured only when a customer order is placed) eliminates the disadvantages of hybrid systems.

In this work, we consider hybrid push-pull system with a decoupling point at the inventory of semi-finished products. Here, after an order is received, only the final completion step still needs to be done. The decoupling inventory system is modelled as a two-buffer Markovian queueing system with one finite and one infinite buffer. Indeed, to limit the involved costs, the decoupling stock needs to be sufficiently small. Hence,

finite capacity is a natural assumption. In contrast, no such assumption is imposed for the other queue: the order backlog queue has an infinite capacity. Comparing versatility and numerical tractability, we study the decoupling stock in a Markovian environment [1]. This approach allows for studying the effect of variability in the production process and the ordering process on the performance of the decoupling stock.

Methodology and numerical results

The studied Markov process is a homogeneous quasi-birth-and-death process (QBD) [2]. In the present setting, the so-called level or block-row number, indicates the number of waiting orders while the phase, i.e. the index within a block element, indicates both the content of the decoupling stock and the state of the Markovian environment. Matrix-analytic techniques to find the stationary distribution of the QBD processes are applied and yield performance measures — like mean order backlog content, average lead time, etc. — of the decoupling inventory system at hand fast.

By numerical examples, we can quantify expected system behaviour - e.g. more production and order delivery yield higher queue content, higher buffer capacity mitigates blocking of the production, etc. In addition, less expected behaviour was observed - e.g. system performance is highly sensitive to the arrival process parameters and reasonably insensitive to the variance of the order processing time distribution. Furthermore, we evaluated the overall cost of a hybrid push-pull system, accounting for the service level calculated in terms of the lead time probability distribution and the average stock of the semi-finished products.

Future work will focus on determining the optimal replenishment strategy of outsourced semi-finished products in hybrid push-pull systems. In terms of cost, we will account for holding, shortage and order costs.

References

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