Multi-Objective Lead-Time Control Problem with Stochastic Constraints

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ABSTRACT
This research intends to find out any development of a robust multi-objective for lead time optimal control problem in a multi-stage assembly system model. Assembly system modeling is possible by the help of the open queue network. A working station includes one or infinite servers and just manufacturing or assembly operations are performed therein. Each part has a separate entry process and independent of each other. It is completely based upon Poisson process.Serving Lead Time of Stations are also independent of each other and therefore exponential distribution of each parameter is controllable. All stations have bounded uncertain unrecyclable wastes which are completely independent in compliance with Erlang distribution. Uncertainty in the problem parameters has been suggested as robust multi-objective optimal control model in which we have three incompatible target functions including cyclic operation cost minimization, average lead time minimization and lead time variance. Finally, target progress method has been applied in order to achieve serving optimal speeds and solve discrete time of the main problem approximately. The proposed model could present a suitable solution even for the same problem as mentioned in other related papers along with some considerable results in parameter uncertainty conditions.

Keywords: Multi-objective planning, robust optimization, lead time control, queue theory, complex assembly system.

1. Introduction

Optimization of the problems which are related to queue system is very complex. In literature, there are many problems which are related to queue systems (Smith et al, 1988). Following goals of this paper are: production, programming, improving throughput, deceasing sojourn time and the average number of the client in the system. Controlling servicing speed in each node of the system studied by Jackson package. Schechner et.al (1989) considered maintenance & operation costs. They assumed that costs are functions of the activity frequency which are performed on a node. Tseng and Hsiao (1995) studied optimal control of a queue system input with two stations under constraint of time delay in system in order to maximize throughput in the system. Kerbache and Smith (2000) studied optimal routing and positioning problems from the point of view of system optimization. Baldoquin et.al (2014) and Chen et al (2014) studied a new model for controlling and optimizing servicing speeds and speeds of entry to servicing stations. They intended to optimize waiting length of the system route and total operational costs of their service stations in each period. In all studies performed so far, hypothesis of model parameters certainty were considered as a main hypothesis while many optimization problems were facing with the uncertainty of the parameters. For example, actual demand of products, financial return, required material and other sources are not known in the supply chain at the time of critical decision making. Input parameters of each server, in queue system optimization problems, may face with uncertainty. The optimal answer obtained from the made models may not be optimal or justified due to violation of some constraints as soon as the parameters take any values other than nominal value.

This may result in a natural question in designing of approaches for finding the optimal answer which is safe against the uncertainty of the parameters. They are called Robust Answers. In order to explain the importance of the most robust answer in applications, we refer to a case study which was done by Ben-Tal and Nemirovski (2000) on linear optimization through Net lib.

We can't neglect that negligible uncertainty in parameters can make optimal normal answer meaningless from the applied point of view In applications of linear programming.

In classic methods, sensitivity analysis and stochastic programming are used in order to consider the uncertainty of the parameters. In the first approach, analyst neglects any effects of parameter uncertainty on the model and uses sensitivity analysis in order to confirm the obtained answers. Parameter Sensitivity Analysis is really a tool for analyzing good answers and we can't apply it for production of robust answers. In addition, it is not practical to do sensitivity analysis on the models with many uncertain parameters.

Dantzing (1998) has defined stochastic programming as an approach for modeling uncertainty of the parameters. This approach assumed scenarios with different probabilities of occurrence of parameters. In this approach, justifiability of the answer is expressed by the use of chance constraints. There are three main problems for this approach as follows: A-It is difficult to recognize accurate distribution of uncertain parameters and finally quantify the scenarios which are obtained from the concerned distributions, B- Chance constraints exclude convexity of the main problem and increase the complexity, C- Dimensions of the obtained optimization model may be increased astronomically in parallel with the increase of the number of scenarios which causes major calculation challenges.

Robust optimization is another approach which has been introduced for confronting with uncertainty of parameters. In this approach, we have to seek for near optimal answers. On the other hand, we ensure justifiability of the answer by decreasing optimization of the target function. In case of uncertainty in target function coefficients, we should search to find the answer which is better than initial ones with high probability of changing target function.

This article presents an approximate model for controlling and optimizing servicing speed (capacity) in each node in the multiphase assembly system and on the basis of the goals of Baldoquin et.al (2014).

2. Multiphase dynamic assembly systems

A multiphase dynamic assembly system can be modeled as an open queue system. A servicing station is embedded in each node and is regarded as an assembly or production operation. The following hypotheses are considered:

Each separate part of the product enters a production system under Poisson process with parameter of λ. Just one product is produced. Servicing station is regarded as a production station with more than an input edge as a production station. A servicing station with more than one input edge is regarded as an assembly station. Each party enters into production station after entering the system to perform production operations on it. If another part is being produced, the new part will be in queue. After completion of process in production station, a part which enters into another station would be exposed to other operations. After production of each part, the concerned part is assembled with other parts in assembly station. The product is completed in end node and leaves the system. Each part has some specifications which are statistically independent of the other parts. Each servicing station comprises one or infinite number of servers. Operation time in servicing stations follows an exponential distribution and is independent of the previous operation time. There is no pause in operations due to failure, repair or other cases. Servicing rule is based on FIFO method. Capacity of queue of all stations is infinite. Transportation times between servicing stations are independent random variables with Erlang distributions. There is a queue system in a stable state. The capacity of the station is controlled by servicing speed of concerned device. Servicing speeds are stepwise variables. Operational costs of a servicing station in each period are ascending functions of servicing speed of that station. Thre are totally two service