Title	自動搬送システムにおける衝突確率の解析
Author(s)	千葉，英史
Citation	
Issue Date	2006-03
Type	Thesis or Dissertation
Text version	author
URL	http://hdl.handle.net/10119/970
Rights	
Description	Supervisor:浅野　哲夫，情報科学研究科，博士

Analysis of Collision Probability in Automatic Transportation Systems

Eishi Chiba
School of Information Science
Japan Advanced Institute of Science and Technology

Abstract: Manufacturers of semiconductor and liquid crystal must keep creating good manufacturing equipment to be selected in the large fierce competitions. The manufacturer which creates better manufacturing equipment than other manufacturers is one which approaches essence of manufacturing equipment as close as possible. In fact, there is no complete thing on mathematical model and performance evaluation of manufacturing equipment yet. Therefore, persons in charge of manufacture and researchers continue to challenge such unknown thing.

There are various models on manufacturing equipment. In classic machine scheduling, processing time of job is deterministic and objective is usually to determine an optimal ordering of jobs to be processed in each machine.

In contrast, actual manufacturing equipment of semiconductor or liquid crystal is in a totally different situation from the machine scheduling. It is a mass-production system designed to produce one kind of product in large quantities. There is, therefore, no point in finding a good ordering of jobs. Moreover, actually interarrival time is not constant and processing time at each machine also changes due to environment. Therefore, we assume that each interarrival time and processing time follow a probability distribution. Under such circumstances, it is common to analyze such system by using queuing theory.

Queuing model mainly is expressed by using the distribution of interarrival times of jobs, the distribution of processing times at each machine and the number of machines. Research of queuing is done actively, therefore many results of analysis are known. But, we cannot apply those results to our queuing model on actual manufacturing equipment. Because arrival and processing distributions which are usually used in queuing theory and ones which are used in our model on actual manufacturing equipment are different. Therefore, it is difficult to analyze our model even if the model is a basic cascade of machines connected in line. Moreover, each one of actual manufacturing equipments usually has complicate constraints. Those constraints make it increasingly difficult to analyze actual model.

In this paper, we model a tandem transportation system which represents manufacturing equipment of semiconductor, liquid crystal, etc. and analyze the collision probability among jobs which flow through the transportation system. In our model, we assume that the distribution of processing times is a normal distribution which reflects the actual situation. Moreover, we analyze the collision probability when the distribution of processing times is an exponential distribution. The exponential distribution does not reflect the actual situation, but we obtain an intriguing result under such assumption. When each processing time follows a normal distribution, the collision probability generally contains multiple integration. Therefore, robust computation of the probability may be hard due to some computational error. In contrast, the collision probability does not contain multiple integration when each processing time follows an exponential distribution. We obtain such advantageous result by using some properties of the exponential distribution. Therefore, it is easy to compute the probability.

Next, we show a simulation program which checks whether a collision occurs or not. When each processing time follows a normal distribution, it is hard to evaluate the collision probability as discussed previously. But, we can easily compute the collision probability by using this simulation program. Moreover, we can find that both probabilities by simulation and theory are almost the same in some cases. Therefore, when we want to evaluate the collision probability in real situations, we can use a result of this simulation program.

Moreover, when we assume that each machine in the tandem transportation system has some buffers, we have computed the collision probability by using a simulation program. From the results, it turns out that the collision probability becomes dramatically low only by preparing one buffer in each machine. Actually, when the tact time is set as the average value of the processing time of each machine, we can find that collision probability is quite low and it is about 0. Moreover, from the simulation results, we have also obtained the property that collision probability hardly changes even if the number of machines increases. The property is advantageous in real situations because actual manufacturing equipment consists of several hundred machines.

Finally, other problems which are afflicting the persons in charge of manufacture are also described. Transportation scheduling problem is the problem of finding an optimal transportation schedule in multi-commodity manufacture lines. We formulate this problem as a decision problem and prove that this problem is NP-complete. We also present a deterministic polynomial algorithm for the problem under a constraint. Just-in-time scheduling problem is the problem of finding an optimal schedule such that each job finishes exactly at its due date. We study the problem under a realistic assumption called periodic time slots. In this paper, we prove that this problem cannot be approximated, assuming P$\neq$NP. Next, we present a heuristic algorithm, assuming that the number of machines is one. Our algorithm is fast and has good performance on approximation ratio experimentally. We have also shown some results on approximation ratio under a constraint.