論文 / 著書情報
Article / Book Information

題目(和文)	
Title(English)	Studies on Batch Arrival Infinite-Server Queues and Related Models
著者(和文)	矢島萌子
Author(English)	Moeko Yajima
出典(和文)	学位:博士(理学), 学位授与機関:東京工業大学, 報告番号:甲第11392号, 授与年月日:2020年3月26日, 学位の種別:課程博士, 審査員:三好 直人,樺島 祥介,渡邊 澄夫,福田 光浩,中野 張,増山 博之
Citation(English)	Degree:Doctor (Science), Conferring organization: Tokyo Institute of Technology, Report number:甲第11392号, Conferred date:2020/3/26, Degree Type:Course doctor, Examiner:,,,,,
学位種別(和文)	博士論文
Category(English)	Doctoral Thesis
種別(和文)	論文要旨
Type(English)	Summary

（博士課程）
Doctoral Program

論 文 要 旨

THESIS SUMMARY

系・コース： Department of, Graduate major in	数理・計算科学 系 数理・計算科学 コース	申請学位（専攻分野）： Academic Degree Requested	博士 （ 理学 ） Doctor of
学生氏名： Student's Name	矢島萌子	指導教員（主）： Academic Supervisor(main)	三好直人
		指導教員（副）： Academic Supervisor(sub)	

要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

Queueing theory is a mathematical approach to the analyses of congestion in waiting lines, and queueing models are used to imitate waiting lines in queueing theory. In general, queueing theory is considered to be a division of operations research, because the analysis results of queueing models are often used to make decisions about resources in order to provide service. This thesis studies batch arrival infinite-server queues and related models. Infinite-server queues have infinitely many servers, and thus all arriving customers can receive service without waiting. Infinite-server queues have many applications in various areas, such as inventory systems, road traffic systems, and telecommunication systems. In addition, infinite-server queues help us to understand the dynamics of customers in large-scale service systems (facilities), such as theme parks, large commercial complexes, and large parking lots.

Stability conditions for infinite-server queues with batch-arrivals are paid little attention in previous studies, where the stability condition is the necessary and sufficient condition that the queue length process has a proper and non-degenerate limiting distribution. If the queueing model is not stable, there exist customers who cannot finish receiving service in a finite time with a positive probability. Thus, the stability is an important property in applications of queueing models. This thesis presents stability conditions for general batch arrival infinite-server queues. We first consider the stability for BMAP/M/∞ queues, which are infinite-server queues with a batch Markovian arrival process (BMAP) and an exponential service time distribution. We show that the stability condition for BMAP/M/∞ queues is that the logarithmic moment of batch sizes is finite. Furthermore, we extend this result to the multiclass BMAP/M/∞ queues. Next, we investigate the stability for GI^X/GI/∞ queues, which are infinite-server queues such that batches arrive according to a renewal process and service times of customers are independent and identically distributed with a general distribution. We show the stability condition for GI^X/GI/∞ queues. We also show a tractable sufficient condition for the stability under a moderate condition on the tail of the service time distribution. Furthermore, in the case that the service time distribution has an exponential tail, we show that the stability condition for the GI^X/GI/∞ queue is that the logarithmic moment of the batch size is finite.

Markov-modulated queues change their parameters depending on a Markov chain being independent of the system. Due to dependence of the parameters on the background process, Markov-modulated queues can imitate more complex situation than queueing models with constant parameters. This thesis analyzes a Markov-modulated infinite-server queue with catastrophe mechanism, where catastrophe mechanism can imitate accidents inducing departure of customers. In general, it is very difficult to exactly analyze Markov-modulated queues, except for some simple models. Thus, we consider the scaling model in a heavy traffic regime. We then establish a central limit theorem for the stationary queue length; that is, the centered and normalized stationary queue length distribution converges in distribution to a normal distribution. Furthermore, we derive an approximation of the stationary queue length distribution using the central limit theorem, and then confirm the accuracy of this approximation through numerical experiments.

In today's information society, it is a serious issue that energy consumption and transmission delay in data centers increase. In recent year, variable-speed CPUs have become popular because they can reduce energy consumption while maintaining acceptable transmission delay for jobs. Furthermore, a simple idea for reducing energy is to adopt the on-off policy: that is, the server is turned off when the system becomes empty, and the OFF server is reactivated when a new job arrives at the empty system. However, a setup time is needed in order to reactivate the OFF server. Servers cannot process jobs during the setup, but consume energy. Thus, turning off the server may or may not reduce energy consumption but increases the transmission delay. In order to see the dynamics of data centers with a variable-speed and power-aware CPU, we studied batch arrival single-server queues with variable service speed and the on-off policy. In particular, we assume that the service speed changes in proportion to the queue length. The queue length process of this single-server queue is identical to that of an infinite-server queue. We derive the probability generating function of the stationary queue length and the Laplace-Stieltjes transform of the stationary sojourn time distribution. In addition, we present some numerical results to show the energy-performance of the queueing model analyzed herein.

備考 ： 論文要旨は、和文 2000 字と英文 300 語を 1 部ずつ提出するか、もしくは英文 800 語を 1 部提出してください。
Note : Thesis Summary should be submitted in either a copy of 2000 Japanese Characters and 300 Words (English) or 1copy of 800 Words (English).