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An Unreliable Batch Arrival Retrial Queueing System With Bernoulli Vacation Schedule and Linear Repeated Attempts: Unreliable Retrial System With Bernoulli Schedule

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ABSTRACT

This article deals with the steady-state behavior of an $M^X/G/1$ retrial queue with the Bernoulli vacation schedule and unreliable server, under linear retrial policy. Breakdowns can occur randomly at any instant while the server is providing service to the customers. Further, the concept of Bernoulli admission mechanism is introduced. This model generalizes both the classical $M^X/G/1$ retrial queue with unreliable server as well as the $M^X/G/1$ retrial queue with the Bernoulli vacation model. The authors carry out an extensive analysis of this model. Namely, the embedded Markov chain, the stationary distribution of the number of units in the orbit, and the state of the server are studied. Some important performance measures and reliability indices of this model are obtained. Finally, numerical illustrations are provided and sensitivity analyses on some of the system parameters are conducted.

KEYWORDS

Classical Retrial Policy, Random Breakdown, Reliability Indices, Stationary Distribution

1. INTRODUCTION

Retrial queues (or queues with repeated attempts) are characterized by the feature that a customer that finds, upon arrival, the server busy, is obliged to leave the service area and repeat his demand for service after some time called "retrial time." Between trials, the blocked customer joins a pool of unsatisfied customers called "orbit." Queues in which customers are allowed to conduct retrials have been widely used to model many practical problems in telephone switching systems, telecommunication networks and computers competing to gain service from a central processing unit. Moreover, retrial queues are also used as mathematical models for several computer systems such as packet switching networks, shared bus local area networks operating under the carrier-sense multiple access protocol and collision avoidance star local area networks etc. For a review of the main results and methods, the reader is referred to the survey papers of Yang and Templeton (1987), Falin (1990), Kulkarni

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and Liang (1997) and the book by Falin and Templeton (1997). For more recent references, see the bibliographical overviews in (Artalejo 2010; Artalejo, 1999; Artalejo, 1999). Further, a comprehensive comparison between retrial queues and their standard counterparts with classical waiting lines can be found in Artalejo and Falin (2002).

Many of the queueing systems with repeated attempts operate under the classical retrial policy, where each block of customers generates a stream of repeated attempts independently of the rest of the customers in the orbit, i.e., the intervals between successive repeated attempts are exponentially distributed with rate $n\theta$ (say), when the number of customers in the orbit is n. However, there is a second kind of policy, called constant retrial policy, which arises naturally in problems where the server is required to search for customers (Sengupta 1990) and in communication protocols of type carrier sense multiple access (CSMA). The latter discipline was introduced by Fayolle (1986), who investigated an M/M/1 retrial queue in which the repeat customers form a queue and only the head customers of the orbit queue can request a service after an exponentially distributed retrial time with some parameter γ (say), i.e., the retrial rate is $(1-\delta_{0,n})\gamma$, where $\delta_{i,j}$ denotes the Kronecker's delta, when the number of units in the orbit is n. Farahmand 1990) called this discipline a retrial queue with FCFS orbit retrial policy. Choi et al. (1992) generalized this retrial policy by considering an M/M/1 retrial queue with general retrial times. Artalejo and Gomez-Corral (1997) introduced a more general kind of retrial incorporating both possibilities by assuming that when there are n customers in the system, the time intervals between successive repeated attempts are exponentially distributed random variables with parameter $\theta_n = (1-\delta_{0,n})\gamma$, where θ can be considered as the retrial per customer and γ the rate at which the server seeks service for customers whenever it is idle. Such a type of retrial policy is known as a linear retrial policy. Recently, Choudhury (2008) investigated such a queueing model for two phases of service under Bernoulli vacation schedule.

The classical vacation scheme with Bernoulli service discipline was originated and significantly developed by Keilson and Servi (1986) and co-workers. Kella (1990) suggested a generalized Bernoulli scheme according to which a single server goes on i consecutive vacations with probability p_i if the queue is empty upon his return. At the end of a vacation period, service begins if a customer is present in the queue. Otherwise, the server waits for the first customer to arrive. A wide class of retrial policies for governing the vacation mechanism has also been discussed in the literature. Most of the analyses for retrial queues concerns the exhaustive service schedule (Artalejo, 1997), gated service policy (Langaries, 1999) and recently modified vacation policy (Ke & Chang 2009). A number of papers (Ke & Chang, 2009; Krishnakumar & Arivudainambi, 2002; Krishnakumar et al., 2002; Wenhui, 2005) have recently appeared in the queueing literature in which the concept of Bernoulli vacation schedule has been introduced under the FCFS orbit retrial policy. Such type of queueing models occurs in many real-life situations where the server may be used for other secondary jobs, for instance to serve customers in other systems. Allowing the server to take vacations makes the queueing model more realistic and flexible in studying real-world queueing situations. Applications arise naturally in call centers with multi-task employees, customized manufacturing, telecommunication and computer networks, maintenance activities, production and quality control problems, etc.

The study of queueing models with service interruptions goes back to the 1950s. Among some early papers on service interruptions, we refer the readers to see the papers by Gaver (1962), Avi-ltzhak and Naor (1963), Thirurengadan (1963) and Mitrany and Avi-ltzhak (1968) for some fundamental works. Li et al. (1997), Sengupta (1990), Takin and Sengupta (1998), Tang (1997), among others, have studied some queueing systems with interruptions where, in one of the underlying assumptions, the service channel undergoes repair instantaneously, as soon as it fails. Recently, Lee (2018) considered a model where the breakdowns/repair process is non-stationary in the number of breakdowns/repairs. On the other hand, retrial queues that take into account servers failures and repairs were introduced by Aissani (1988) and Kulkarni and Choi (1990). As related literature, we should mention some papers by Aissani (1994; 1993), Aissani and Artalejo (1998) and Anisimov and Atadzhanov (1994). Wang

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