A SURVEY ON WORKING VACATION QUEUEING MODELS

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Abstract: In this survey, we briefly study on variants of arrival and service processes with different types of working vacation models. The concept of working vacations has wide range application in computer communication systems, manufacturing/production systems and inventory systems in particularly network service, web service, file transfer service and mail service etc. The motivation of this work is to provide sufficient information to analysts, managers and industry people who are interested in using queuing theory to model congestion problems and want to locate the details of relevant models.

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1. Introduction

In queueing theory, vacation queues have been intensive research topics for long time; there has been considerable attention paid to the queueing models with server vacations since Levy and Yechiali [17]. Queueing systems with server vacation have been investigated extensively due to their wide applications in several areas including computer communication systems, manufacturing and production systems and inventory systems. In a vacation queueing system, the server may not be available for a period of time (utilize the idle time for different purposes) due to many reasons like, being checked for maintenance,
working at other queues, scanning for new work (a typical aspect of many communication systems) or simply taking break. This period of time, when the server is unavailable for primary customers is referred as a vacation. For more detail on this topic various excellent surveys on server vacation models in the queueing literature can be found in, Doshi [8], Takagi [35], and Tian and Zhang [38] and the references therein. A recent survey by Ke et al. [14] and Tian et al. [40] described the latest research results on vacation and working vacation queueing systems in the past decade.

Working vacation (WV) is one kind of vacation policy under which the server provides service at a lower speed during the vacation period rather than stopping service completely. This queueing model can be used to some practical systems like network service, web service, file transfer service and mail service etc. It was introduced by Servi and Finn [32] in an M/M/1 queueing system. They studied an M/M/1 queue with working vacations, and obtained the transform formulae for the distribution of the number of customers in the system and sojourn time in steady state, and applied these results to performance analysis of gateway router in fiber communication networks. During the working vacation models, the server cannot come back to the regular busy period until the vacation period ends. Furthermore, during the WV period, if there are customers at a service completion instant, the server can stop the vacation and come back to the regular busy state. This policy is called vacation interruption.

In this survey, we briefly survey of the studies on variants of arrival and service processes with different types of working vacation models for the past decade. It will be useful for the readers in the area of working vacation queues. The rest of the paper is organized as follows: In Section 2, we discussed on the recent models with M/M/1 and M/G/1 queueing models with working vacations. Section 3 reviews the models dealing general input model for GI/M/1 and GI/G/1 queueing system with working vacations. Section 4 presents the recent works on retrial queue with working vacation models. Other recent developments of working vacation models are reported in Section 5. Finally, conclusion and summary of the work is presented in section 6.
active during the vacation period which is called working vacation (WV). Servi and Finn [32] introduced this class of semi-vacation policy. They studied an M/M/1 queue with multiple working vacations (MWVs). Wu and Takagi [45] generalized Servi and Finns [32] M/M/1/WV queue to an M/G/1/WV queue. Kim et al. [15] analyzed the queue length distribution of an M/G/1 queue with WV.

Liu et al. [27] derived the stochastic decomposition results in an M/M/1 queue with WV. Zhang and Xu [48] studied an M/M/1 queue with multiple working vacations and the N-policy by using a quasi-birth-and-death (QBD) process and a matrix-geometric solution method. An M/G/1 queue with exponential WV was analyzed by Li et al. [21]. Jain and Jain [13] studied a working vacation queue with multiple types of server breakdowns, where each type of breakdown requires a finite random number of stages of repair. However, the bulk input queue models have more extensive applications in the computer networks and communication systems. For the batch arrival queues, Xu et al. [46] studied an $M^X/M/1$ queue with single working vacation by using matrix analytic method. Baba [4] extended a batch arrival $M^X/M/1$ queue with MWV. The probability generating function of the stationary system length distribution is derived by using quasi upper triangular transition probability matrix of two-dimensional. Recently, Gao and Yao [11] developed an $M^X/G/1$ queue with randomized working vacations and at most $J$ vacations.

For the vacation interruption models, Li and Tian [19] first introduced it in an M/M/1 queue. During a WV period, the server can interrupt the vacation at a service completion instant if there are customers in the system. This is known as working vacation with vacation interruption and it was applied to an M/G/1/MWV queue by Zhang and Hou [49]. Tian et al. [39] studied an M/M/1 queue with SWV using matrix geometric method. Zhang and Hou [52] analyzed an M/G/1 queue with working vacations and vacation interruption. Using the method of a supplementary variable and the matrix analytic method, the queue length distribution and service status at an arbitrary epoch under steady state conditions are obtained.

Li et al. [23] studied an M/G/1 queue with set-up time and multiple working vacations. They obtained the numbers of customers in the system at the departure instants, and then they deduced the state transition matrix by using the method of embedded Markov chain. Gao and Liu [9] recently introduced a single working vacation and Bernoulli-schedule vacation interruption policy into an M/G/1 queue. Based on the previous work, Lee and Kim [16] have studied sojourn time distribution of an M/G/1 queue with a single working vacation and vacation interruption. They derived the explicit LST of the sojourn time.
distribution of this model. Selvaraju and Cosmika [31] analyzed an M/M/1 impatient customer queue with single and multiple working vacations.

Recently, Vijayalaxmi and Jyothsna [42] presented the Performance analysis of variant working vacation queue with balking and reneging. A renewal input finite buffer multiple working vacation queue with balking has been studied by Vijayalaxmi and Jyothsna [7]. Yang and Wu [47] have studied the cost-minimization analysis of the N-policy M/M/1/WV queue with server breakdowns. Zhang and Liu [53] developed the working vacations and vacation interruption in M/G/1 queue with negative customers and the server breakdown.

3. The GI/M/1 and GI/G/1 Queues with Working Vacation

For general input models, Baba [3] investigated the study of a GI/M/1 queue with working vacation by the matrix analysis method. Banik et al. [5] discussed the GI/M/N queue with working vacations and presented a series of numerical results. Li and Tian [18] connected working vacation and vacation interruption and analyzed the discrete-time GI/Geom/1 queue with working vacation and vacation interruption. Later, Li et al. [20] analyzed the GI/M/1 queue with working vacations and vacation interruption. Using the matrix analysis method, they obtained various performance measures such as mean queue length and waiting time. Further, setup period for GI/M/1 queue with working vacation and vacation interruption proposed by Zhao et al. [54].

Chen et al. [6] expressed the GI/M/1 queue with PH working vacations and vacation interruption such that the vacation time follows a Phase-type (PH) distribution. Li and Tian [22] discussed the GI/M/1 queue with single working vacation. Using the matrix analytic approach, the steady state distributions of the number of customers in the system at both arrival and arbitrary epochs are obtained.

Zhang and Hou [50] studied a GI/M/1/N queue with a variant of multiple working vacations, employing the supplementary variable and embedded Markov chain methods, the queue length distribution at different time epochs are obtained.

Tao et al. [36] proposed a new GI/M/1 queue with start-up period and single working vacation and vacation interruption at the same time. Using the matrix-analytic method, they obtained the steady-state distributions for the queue length at arrival epochs, arbitrary epochs, the waiting time and sojourn time.

Vijayalaxmi and Jyothsna [42] analyzed the finite buffer GI/M/1 multiple
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working vacations queue with balking that has potential applications in manufacturing, transportation, communication systems, etc. Goswami et al. [12] analyzed a finite buffer renewal input queueing system with state-dependent services and state-dependent multiple working vacations. Later in 2013, Vijayalaxmi et al. [43] developed a model with incorporation of single working vacation and vacation interruption.

Recently, Vijayalaxmi and Suchitra [44] studied the model for finite buffer GI/M(n)/1 queue with multiple working vacations and changeover time, where the server can keep on working but at a slower speed during the vacation period.

4. Retrial Queueing Models with Working Vacation

Vacation queues and retrial queues have been applied to evaluate the performance of various systems. In the recent studies, many of the researchers discussed about the concept of retrial queues with working vacation.

The retrial queueing system is characterized by an arriving customer which finds the server busy, leaves the service area and repeats its demand after some time. Between trials, the blocked customer joins a pool of unsatisfied jobs called orbit, for example, web access, telecommunication networks, packet switching networks, collision avoidance, star local area networks, etc.

The M/M/1 retrial queue with working vacations was introduced and analyzed by Do [7]. Li et al. [23] gave a Geo/Geo/1 retrial queue with working vacations and vacation interruption.

Liu and Song [28] introduced a non-persistent customers and working vacations into the discrete time Geo/Geo/1 retrial queue. Using the matrix-analytic method, they obtained the stationary probability distribution and some performance measures and showed the conditional stochastic decomposition for the queue length in orbit.

Recently, Arivudainambi et al. [2] first explored an M/G/1 retrial queueing system with single working vacation. Gao et al. [10] considered an M/G/1 retrial queue with general retrial times, and introduce working vacations and vacation interruption policy into the retrial queue. Using supplementary variable method, the stationary probability distribution and some performance measures are obtained. Furthermore, they found the waiting time distribution and proved the conditional stochastic decomposition for the queue length in orbit.

Aissani et al. [1] discussed an M/G/1 retrial queue with working vacation. They obtained generating functions allow us to obtain several other performance measures such as the mean waiting or the mean sojourn time.
Very recently, Rajadurai et al. [29] and [30] developed retrial queueing models with the concept of working vacation and vacation interruption in presents of breakdowns.

5. Other Working Vacation Models

Another recent development in working vacation model research is on the system with Markov Arrival Process (MAP). Zhao and Cui [55] have investigated PH approximation for the MAP/G/1 queue with N-policy working vacation.

Zhang and Hou [51] studied the MAP/G/1 queue with working vacations and vacation interruption. They obtained the queue length distribution with the method of supplementary variable, combined with the matrix-analytic method and censoring technique and also found the system size distribution at pre-arrival epoch and the Laplace-Stieltjes transform (LST) of waiting time.

Sreenivasan et al. [33] extended the work of Li and Tian [19] to MAP arrivals and phase type services and introduced the N-policy vacation in this model. Recently, Liu et al. [26] studied a cold standby repairable system with working vacations and vacation interruption following Markovian arrival process.

6. Conclusions

There are many extensive works have been done in the vacation model area over the past three decades as surveyed in Doshi [8], Takagi [35], Tian and Zhang [38] and some survey papers Tian et al. [40] and Ke et al. [14] including this paper. In this work, we presented short survey of the studies on variants of arrival process and service processes in working vacation queueing models. The idea discussed in various papers has been synthesized. It can help statisticians, operations analyst, researchers, engineers, managers for using these models. A wide range of literature has been covered and proper references have been cited.

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References


