Abstract

This thesis deals with the optimal, parametric, and sensitivity analyses of several Markovian service models and machining systems using the queueing-theoretic approach. The present study deals with single and multi-server real-time service systems in different strategical designs and assumptions, namely, server vacation policies, working vacation policies, arrival and server control policies, impatient behavior of customers et cetera. For the predictive purpose, the cost optimization problems are formulated in terms of inheriting parameters and associated quality performance measures of the queue-based service systems subject to constraints of resources. For suggesting the optimal operating conditions, several heuristics and metaheuristic optimization techniques are applied, and research findings are tabulated in tables and depicted in different types of plots. The inferential remarks and future directions are also provided for each studied model.

This thesis is divided into three parts and contains nine chapters. Each part is dedicated to a similar type of analysis. The first part is dedicated to the optimal analysis of the service system using nature-inspired optimization techniques. The sensitivity analysis of the queue-based service system is done in the second part. The outcomes are useful to identify the critical parameter(s). In the last part, the transient analysis of the service and machining system is performed. The results are advantageous for developing an efficient service system. Besides review, the brief note of basic introduction about the essential queueing characteristics, queueing terminologies, queueing related processes, methodologies, et cetera in the queueing literature have been discussed in chapter 1. The customer-oriented, server-oriented, and system-oriented specifications are studied in brief and identified for the investigation.

In chapter 2, we deal with the multi-server finite capacity service system with Bernoulli's scheduled modified vacation policy and the realistic retaining policy of reneged customers. In this policy, after completion of the service of any customer, the server decides whether to go for the vacation of random duration or to continue facilitating the service to the waiting customer, if any, present in the queue. We assume that all the homogeneous servers provide the state-dependent service following the threshold policy to reduce the overload of the system. The impatience behavior of customers like balking and reneging is also considered in the stochastic modeling of the studied problem. The matrix analytic approach is employed to obtain the steady-state probabilities with which various system performance measures are developed with practical justification.

In chapter 3, we study the effect of the newly introduced emergency vacation of

a single service provider in the service system via the queueing-theoretic approach. According to this vacation policy, the working server takes a vacation in an emergency without completing the ongoing service of the waiting customer in the system. For the modeling purpose, it is assumed that the inter-arrival times, service times, and vacation times are exponentially distributed. A cost optimization problem is developed to obtain the optimal values of system design parameters. The comparative analysis of the proposed nature-inspired technique bat algorithm (BA) with another well-known metaheuristic technique particle swarm optimization (PSO) and heuristic technique Quasi-Newton method has been done to achieve the optimal operating conditions with minimal expected cost.

The optimal strategies of service systems in the Markovian environment with vacation interruption and synchronized reneging are provided in chapter 4. We consider a realistic phenomenon, synchronized reneging, in which some waiting customers abandon the system following point process with some independent probability of abandon of each customer. We strategic a controllable working vacation policy of random length during which, if the server finds more than a pre-specified number of waiting-customers in the system after completion of service of any customer then server's vacation is interrupted, and the server returns into the standard working attribute immediately to enhance the better services. Some quality performance measures are formulated, and their sensitivity is depicted in different tables and graphs. Additionally, a cost optimization problem is expressed, and the nature-inspired optimization technique, cuckoo search (CS) algorithm, has been employed to establish the optimal operating policy for obtaining a minimal expected cost of the system. To show the practicability of the developed model and to validate the findings obtained by the CS algorithm, a comparative analysis with the particle swarm optimization (PSO) and semi-classical optimization techniques, quasi-Newton (QN) method & direct-search (DS) method has also been presented.

In chapter 5, the investigation is concerned with a randomized arrival control policy for the prospective customers in the finite capacity service system with working vacation and vacation interruption. The impatience behavior of the customers is also considered in modeling and assumptions to make the studied problem more realistic. In the investigated model, at the epoch, when the number of customers in the system reaches the system's capacity, newly arriving customers are not further allowed to join the system and referred to as lost customers. As the length of the queue decreases to a pre-specified threshold value F, the server commences a startup for re-allowing the customers to join the system. The steady-state probability distribution and vector representation of various system performance measures are derived using a matrix analytic approach. The cost optimization problem is also formulated, and

the particle swarm optimization (PSO) algorithm is implemented to determine the optimal decision parameters to achieve the minimum expected cost of the system.

In chapter 6, the direct and straightforward transient solution technique for the state of the system in a single server Markovian queueing model with feedback is presented using the modified Bessel function of the second kind. This technique appears to economize in algebra. The expression for a time-dependent measure of effectiveness, such as an expected number of the customers in the system is derived, and parametric analysis is presented.

In chapter 7, a comparative study of different vacation policies on the reliability characteristics of the machining system is presented. For that purpose, the queueing-theoretic approach is employed, and the Markovian models are developed for various types of vacation policy, namely, N-policy, single vacation, multiple vacations, Bernoulli vacation, working vacation, vacation interruption, etc. For all vacation policies, the reliability and mean time-to-failure ($MTTF$) of the system are compared, and results are depicted in the graphs for quick insights. From this study, readers get a glance to understand about vacation, researchers get a concrete platform to choose appropriate assumptions for their research in machining/service system, or system analyst may opt for suitable vacation policy as per limitation of the system.

In chapter 8, we propose the mathematical study of the stochastic model involve in preventive, corrective, and predictive maintenance policies that require for well-functioning of the fault-tolerant machining system. For that purpose, we develop a machine repair problem in a Markovian environment with standbys provisioning, unreliable service, and vacation interruption. Sensitivity and optimal analysis are done for reliability characteristics and the expected total cost incurred using the PSO algorithm, respectively. Further, a strong recommendation is proposed for the decision-makers for the optimal design of the redundant repairable machining systems.

At the end of the thesis, in chapter 9, we summarize the specific contributions of the research findings of the studied models to the queueing literature. We also delineate the prospects with different realistic terminologies for the service systems.