

Chapter 7

Conclusion and future scope

7.1 General conclusion of the thesis

The thesis deals with modeling and analysis of continuous time single server bulk service queues with system size based balking and queue length dependent vacation. In Chapter 2 and Chapter 3 we have considered infinite buffer Poisson bulk service queue with fixed batch size rule and GBS rule and system size based balking. For analytical analysis we have employed probability generating function method and obtained several distribution of interests. In Chapters 4, 5 and 6 we have discussed the modeling and analysis of finite buffer bulk service queue with queue length dependent vacation. The bulk service rule is considered to follow GBS rule with batch size dependent service, i.e., the service time of the batches vary depending on the size of the batch undergoing service. The two vacation models : Single vacation and multiple vacation are studied in an unified way. Also it is considered that the server goes for vacation of longer or shorter period according to queue length at vacation initiation epoch, viz., for empty queue server takes a longer period of vacation, while when queue is non empty the server slightly modulated their vacation period and goes for a shorter period. The service time and vacation time are considered to follow a general distribution. These queueing models are considered under the Poisson arrival process, compound Poisson arrival and Markovian arrival process. For analytical analysis we have employed embedded Markov chain technique and supplementary variable technique. The former one is used to obtain the joint probability distribution of queue content and server content, queue content and type of the vacation at

service/vacation completion epoch, whereas the latter one is used to obtain a relation between the arbitrary epoch joint probabilities and service/vacation completion epoch joint probabilities, in order to obtain the joint probability distributions of queue content and server content, queue content and type of the vacation at arbitrary epoch. We have also carried out several comparative studies of bulk service queues with vacation under queue length dependent vacation policy with the one when vacation period is independent of queue length. Our various numerical investigation on key performance measures, such as average queue length, average system length, average queue length when server is on vacation and average queue length when server is busy, average number of customer in service, average queue length at vacation initiation epoch, average waiting time in the queue and system and probability of blocking, establish the fact that the queue length dependent vacation policy in bulk service queuing models with batch size dependent service leads to shorter queue (system) length, shorter waiting time of customers in queue (system). Hence, in order to reduce congestion in bulk service queues with vacation one may use queue length dependent vacation policy.

7.2 Contribution of the thesis

In this thesis we have made several contributions toward the study of bulk service queues in two ways, first we investigated the system size based balking behavior of arrivals, which naturally arise due to congestion, by employing the probability generating function method, second we performed supplementary variable technique and embedded Markov chain technique to develop analytic procedure toward the study of vacation models on bulk service queues under batch size dependent service. In short these contributions are

- Firstly, we analyzed the bulk service (with fixed batch size rule and GBS rule) queueing system with system size based balking behavior of the arriving customers. We analytically obtained the closed form expression for the joint probability distribution of the queue length as well as serving batch size. We obtained various useful performance measures. We investigated the impact of the key parameters on the system performance measures through few numerical examples.

- Secondly, we have analyzed queue length dependent vacation models on bulk service queues with batch size dependent service, which in a way helps to reduce the congestion on vacation queues with bulk service that arise in many real world applications in particular modern telecommunication systems. In this setting we come to the conclusion that by the inclusion of queue length dependent vacation policy congestion can be reduced in better way as comparison to other existing vacation queueing models in literature. We have also described how to combine the two vacation moods (SV and MV) in a single analysis.
- Thirdly, we have also analyzed the queue length dependent vacation on bulk arrival bulk service queues with batch size dependent service rule.
- Finally, we have analyzed the queue length dependent vacation in bulk service queueing model under batch size dependent service rule with Markovian arrival process (*MAP*) which is more applicable in telecommunication systems as the traffic in modern communication networks is highly irregular (brusty and correlated). Further a numerical computation procedure is suggested to deal with PH type distributions of service time and vacations time.

7.3 Future scope of study

The analysis presented in this thesis can be extended to analyze more complex vacation queueing models involving correlated arrival processes (*BMAP*), correlated service processes (*BMSP*), etc. Another area of interest may be to analyze these bulk queueing models with more general service rule, i.e., versatile batch service rule, under more general vacation policies like variant of multiple vacation, multiple adaptive vacation policy, Bernoulli vacation, working vacations. Also our present model will helpful to analyze polling model contains two different queueing systems. Further using the similar analytical method presented in this work can be helpful to modeling and analyzing a polling model containing more than two queueing systems.