Chapter 12
Perishable Inventory System with Bi-Level Service System

D. Gomathi
SRM University, India

ABSTRACT
In this chapter we consider a perishable inventory system under continuous review at a bi-level service system with finite waiting hall of size N. The maximum storage capacity of the inventory is S units. We assumed that a demand for the commodity is of unit size. The arrival time points of customers form a Poisson process. The individual customer is issued a demanded item after a random service time, which is distributed as negative exponential. The effect of the two modes of operations on the system performance measures is also discussed. It is also assumed that lead time for the reorders is distributed as exponential and is independent of the service time distribution. The items are perishable in nature and the life time of each item is assumed to be exponentially distributed. The demands that occur during stock out periods are lost. The joint probability distribution of the number of customers is obtained in the steady-state case. Various system performance measures in the steady state are derived. The results are illustrated numerically.

1. INTRODUCTION
In most of the inventory models considered in the literature, the demanded items are directly issued from the stock, if available. The demands that occur during stock-out period are either not satisfied (lost sales case) or satisfied only on receipt of the ordered items (backlog case). In the later case, it is assumed that either all (full backlogging) or any prefixed number of demands (partial backlogging) that occurred during stock-out period are satisfied. For review of these works see Nahmias (1982), Raafat (1991), Kalpakam and Arivarignan (1990), Elango and Arivarignan (2003), Anbazhagan and Gomathi (2011), Gomathi, Jeganathan and Anbazhagan (2012) and Liu and Yang (1999).

But in the case of inventories maintained at service facilities, the demanded items are issued to the customers only after some service is performed on it. In this situation the items are issued not at the time...
of demand but after a random time of service from the epoch of demand. This forces the formation of queues in these models, which in turn necessitates the study of both inventory level and queue length joint distribution. Study of such models is beneficial to organizations that

1. Provide service to customers by using items from a stock;
2. Maintain stock of items each of which needs service such as assembly, initialization, installation, etc.

Examples of the first type include firms engaged in servicing consumer products such as television sets, computers, etc., and that of the second type include firms that supply bicycles which need assembly of its part, that supply food items that need heating or garnishing and computer organizations that need installation and basic services. Berman, Kaplan and Shimshank (1993) have considered an inventory management system at a service facility which uses one item of inventory for each service provided. They assumed that both demand and service times are deterministic and constant, as such queues can from only during stock out periods. They determined optimal order quantity that minimizes the total cost rate.

Elango (2001), has considered a Markovian inventory system with instantaneous supply of orders at a service facility. The service time is assumed to have exponential distribution with parameter depending on the number of waiting customers. Arivarignan, Elango and Arumugam (2002) have extended this model to include exponential inventory system in which the size of the space for the waiting customers is infinite. Arivarignan and Sivakumar (2003) have considered an inventory system with arbitrarily distributed demand, exponential service time and exponential lead time.

As a variant, we consider a continuous review perishable \((s, S)\) inventory system with bi-level service system. For a brief review of perishable inventory system, see Arivarignan, Elango and Arumugam (2002), Elango (2001), Liu and Yang (1999), Nahmias (1982), Perumal and Arivarignan (2002), and Raafat (1991).

The most difficult aspect of many queueing systems is their description. This is so because some systems cannot be adequately described using a simple queueing model with unique mean arrival and service rates. The distinguishing feature of such processes is the existence of mean arrival and service rates which depend on the mode of system operation. The server can be in many modes during the operation period but in only one mode at any given time. Soyster and Toof (1976) have considered the reliability of the production line decreases because of the 2-mode operation on queueing model.

We also assumed that the demand realising according to a Poisson process for the commodity that are issued to the customer after a random time of service perfomed on it. The system has there are two modes of operation: working and under-repair. The system randomly changes from one mode of operation to the other. We have assumed that an item of inventory that makes it into the service process cannot perish while in service. The arrival rate does not depend on the mode of operation, but the service rate is depending on the mode. A \((s, S)\) ordering policy with positive random lead time is adopted. This type of situation occurs frequently in real situations, for example, a unit is produced if and only if the machine is functioning. If a machine breaks down then the system breaks down. Once a break-down is repaired and the machine is put back in operation, the production resumes.
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